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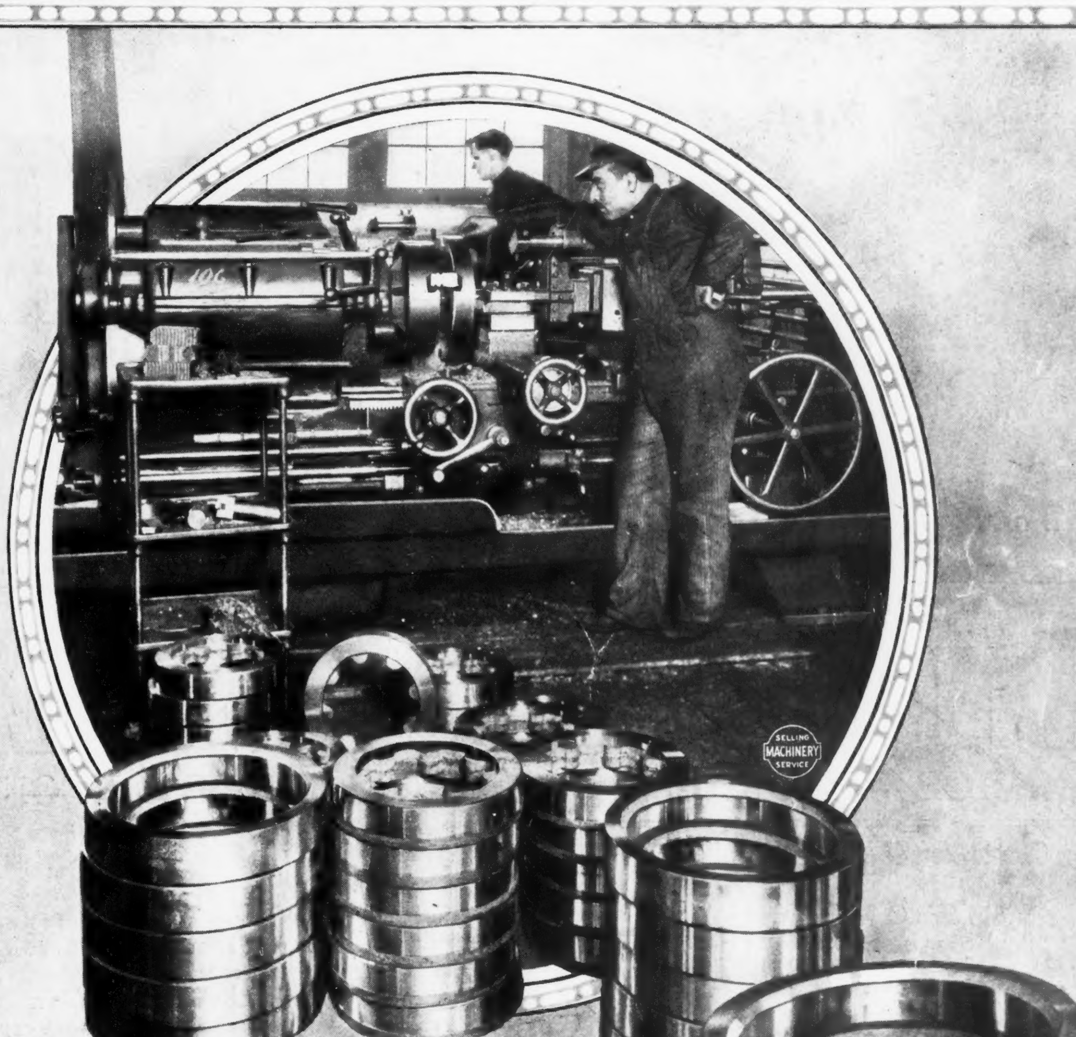




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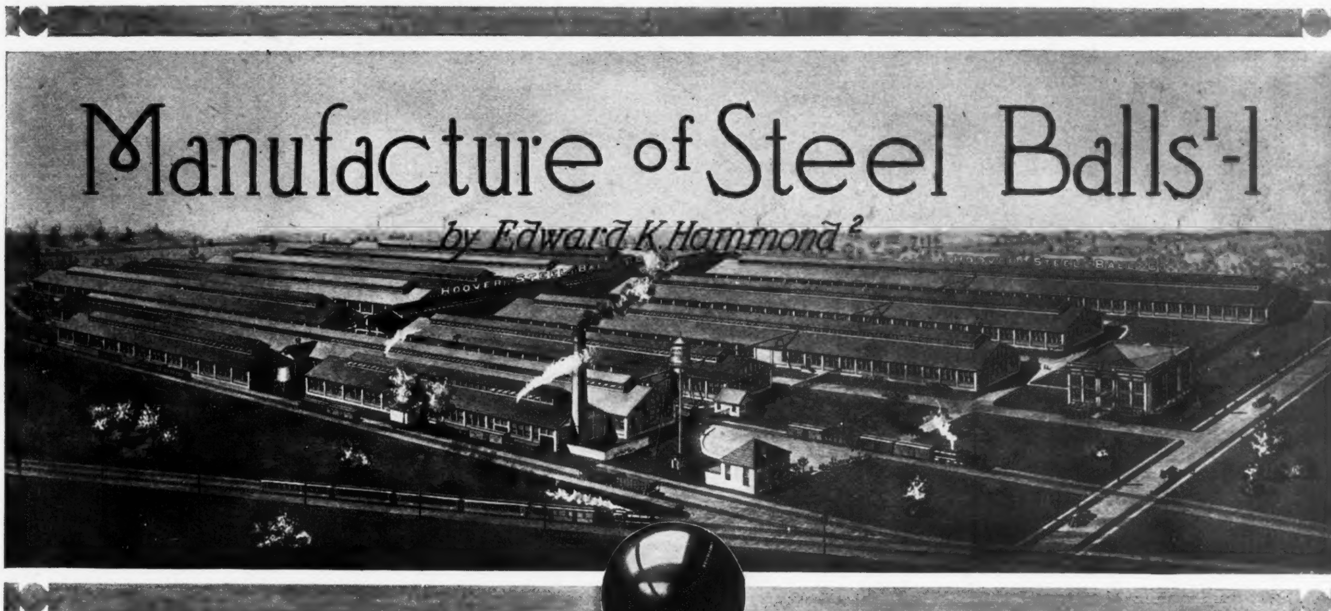
# Manufacture of Steel Balls[1]-I

by Edward K. Hammond[2]



**The manufacture of steel balls is an American industry that has been greatly developed since the outbreak of the European war. This article, which will appear in three installments, will describe the machines and methods of manufacturing balls employed by the Hoover Steel Ball Co., Ann Arbor, Mich., and will take up in detail all the essential processes, including the testing of the steel before manufacture and the gaging and inspection of the finished balls.**

DURING recent years the application of ball bearings in machine design has increased rapidly, and this type of bearing is now used in many machines where plain bearings were formerly considered good enough. Until German export facilities were shut off by the war, the majority of the steel balls used in these bearings were made by the Deutsche Waffen und Munitions Fabriken of Berlin, Germany, and the product of this firm has become so celebrated that many persons think the steel ball industry was developed by the Germans. As a matter of fact, the art of ball making goes back to a very early date, and the development of original methods for doing this work is attributed to the Chinese. To those who have credited the Germans with the development of commercial methods of ball manufacture, it will doubtless be of interest to learn that the first commercial steel balls were made in this country under basic patents granted to Richardson of the Waltham Emery Wheel Co., Waltham, Mass., and that the original ball making machinery for the plant of the Deutsche Waffen und Munitions Fabriken was designed and built in the United States and shipped to Germany ready for use. This will be explained in detail in connection with the following historical outline of important epochs in the steel ball industry.

### How the Steel Ball Industry Came Into Existence

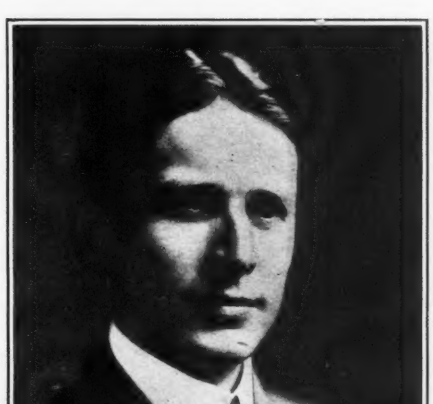
It has been stated that basic patents for dry grinders used in roughing out ball blanks to a spherical form were granted to Richardson of the Waltham Emery Wheel Co., in 1887. These patent rights were subsequently sold to the Cleveland Machine Screw Co., Cleveland, Ohio, which had control of patents on ball making machinery taken out by John J. Grant.

One of the first firms to manufacture steel balls on a commercial basis was the Simonds Rolling Machine Co. of Fitchburg, Mass., and the Fitchburg Steel Ball Co. was subsequently formed by employes who left the Simonds firm. After a brief career, the latter firm was taken over by the Cleveland Machine Screw Co., and with facilities acquired through its own development work and purchase from other companies, it was in a position to manufacture the majority of balls used in the bicycle trade. In this connection it will be of interest to note that up to the year 1899 balls one-half inch in diameter were the largest size that were manufactured in quantities.

About 1890 the Cleveland Machine Screw Co. designed and built for the Deutsche Waffen und Munitions Fabriken, of Berlin, Germany, equipment used in its original steel ball plant, and this marked a most important step in the trade, owing to the reputation for making high-grade balls that was later acquired by this firm. The machines built and shipped to Germany had no reference to American manufacturing rights, and the Cleveland Machine Screw Co. continued to operate its plant in the usual way.

In 1894 when a consolidation of bicycle manufacturers was effected, the Cleveland Machine Screw Co. was sold to the Pope Mfg. Co. of Hartford, Conn., which at that time started to manufacture its own balls for use in bicycle bearings. The requirements of balls for the bicycle trade were not nearly as severe as the standards which must be met by balls used in high-grade annular bearings at the present time. This was largely due to the fact that the cup and cone form of races was employed, allowing compensation to be made, and while this form of race did not enable ball bearings to be operated under the most efficient conditions, it was the means of overcoming discrepancies due to inaccuracies in the size of the balls. Up to this time there had been six or seven firms engaged in the manufacture of steel balls, but with the decline of the bicycle industry a number failed.

In 1901 the Standard Roller Bearing Co., Philadelphia, Pa., acquired all obso-



L. J. Hoover, Vice-president and General Manager, Hoover Steel Ball Co.

[1] For previous articles on the manufacture of balls, published in MACHINERY, see "The Manufacture of Steel Balls," February, March and April, 1912. For other information relating to balls, see "Using Ball Bearings" in the January, 1917, number, and articles there referred to.

[2] Associate Editor of MACHINERY.

lete and existing plants engaged in the manufacture of steel balls. L. J. Hoover, who was formerly in the employ of the Standard Roller Bearing Co., left that firm in 1906 and formed the Grant & Hoover Co. at Merchantville, N. J. The name of this firm was later changed to Atlas Ball Co., and the plant transferred to Philadelphia, Pa., where it is still in operation. On March 1, 1913, the Hoover Steel Ball Co. of Ann Arbor, Mich., was organized by Mr. Hoover for the purpose of engaging in the manufacture of high-grade steel balls to take the place of those imported from Germany. When the European war started in 1914, the blockade of German ports by the British Navy shut off the supply of steel balls formerly exported by that country to the United States, and the insistent demand of consumers for balls made in this country imposed a heavy strain upon the facilities of domestic producers. Somewhat similar conditions existed in all branches of the machinery trade, making it difficult for the ball manufacturers to increase the capacity of their plants; but the management of the Hoover Steel Ball Co. showed commendable initiative by contracting for the entire output of machine building firms with which orders were placed for special machinery required in ball manufacture; and these firms were given financial assistance to enable them to handle work with the greatest possible rapidity. As a result, the Hoover Steel Ball Co. has increased its capacity 600 per cent, the growth being well illustrated by Fig. 1 and the heading illustration, that show, respectively, the original factory in which the firm started manufacturing in March, 1913, and the plant as it appears at present. An idea of the magnitude of the business will be gathered from the fact that the consumption of steel runs in excess of 900 tons a month, and calculated on the basis of 1/4-inch balls, the daily production is between 25,000,000 and 30,000,000 balls per day.

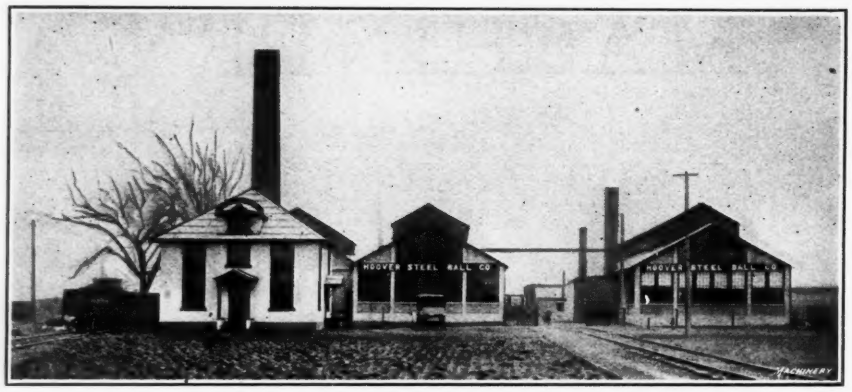


Fig. 1. Original Plant in which Hoover Steel Ball Co. started Manufacturing Operations in March, 1913

### Raw Material of the Steel Ball Industry

The steel from which balls are made comes to the factory in coils or straight rods, according to its size. Stock less than 11/16 inch in diameter comes in coils and is known as "wire," while all stock exceeding 5/8 inch in diameter comes in straight bars. The size of the stock is referred to in thousandths, *i. e.*, stock 3/8 inch in diameter is known as 0.375-inch stock. The following is a typical analysis of steel wire used for making balls: carbon, 1.00 to 1.05 per cent; silicon, 0.25 to 0.30 per cent; manganese, 0.15 to 0.20 per cent; chromium, 0.45 to 0.55 per cent; sulphur and phosphorus, not to exceed 0.02 per cent. The following analysis is typical for the larger sizes of stock which comes in straight bars: carbon, 1.02 per cent; manganese, 0.28; silicon, 0.21; chromium, 0.65; sulphur, 0.016; and phosphorus, 0.014 per cent. A well equipped laboratory is maintained in which chemical and physical tests are conducted on each shipment of steel to determine its suitability for manufacture into balls, and an unloading ticket must be signed by the head of the laboratory before the steel is taken from the cars into the plant. Some very interesting conditions have been brought to light by the laboratory work, and a later section of this article will be devoted to a discussion of tests conducted on the raw material and product, data obtained from these tests, and a description of methods and apparatus used in the laboratory.

### Production of Ball Blanks by Cold-heading

Ball blanks made from stock ranging from 1/16 up to and including 5/8 inch in diameter are formed on special cold-headers designed for the production of ball blanks by the E. J. Manville Machine Co., Waterbury, Conn. A battery of these machines is shown in operation in Fig. 2, and in this connection it may be mentioned that the Hoover Steel Ball Co. is equipped with machines of the following sizes: 00, 0, 1, 2, 3, and 5. Production of ball blanks by the cold-heading process has several advantages in its favor. In the first place, there is practically no waste, with the exception of about 0.040 inch of metal left on the blank to provide for finishing. Blanks can be held to this close limit because the steel is worked cold and there is no tendency for it to become decarbonized. One man can look after three or four machines, so that the cost of labor is almost negligible. Cold-headers used in the production of ball blanks are of the type commonly known as single-blow solid-die machines, and the way in which they operate can best be explained in connection with Fig. 3. These machines consist of a heavy frame *A* which completely surrounds the working parts of the machine, thus insuring a high degree of rigidity. At one end of the machine there is a driving shaft *B*; and at the opposite end of the frame is die-block *C*. Between the sides of the frame is a movable ram *D* that actuates the heading punch *E*. Wire *F* to be made into ball blanks enters the machine through feed rolls *G* and then passes through

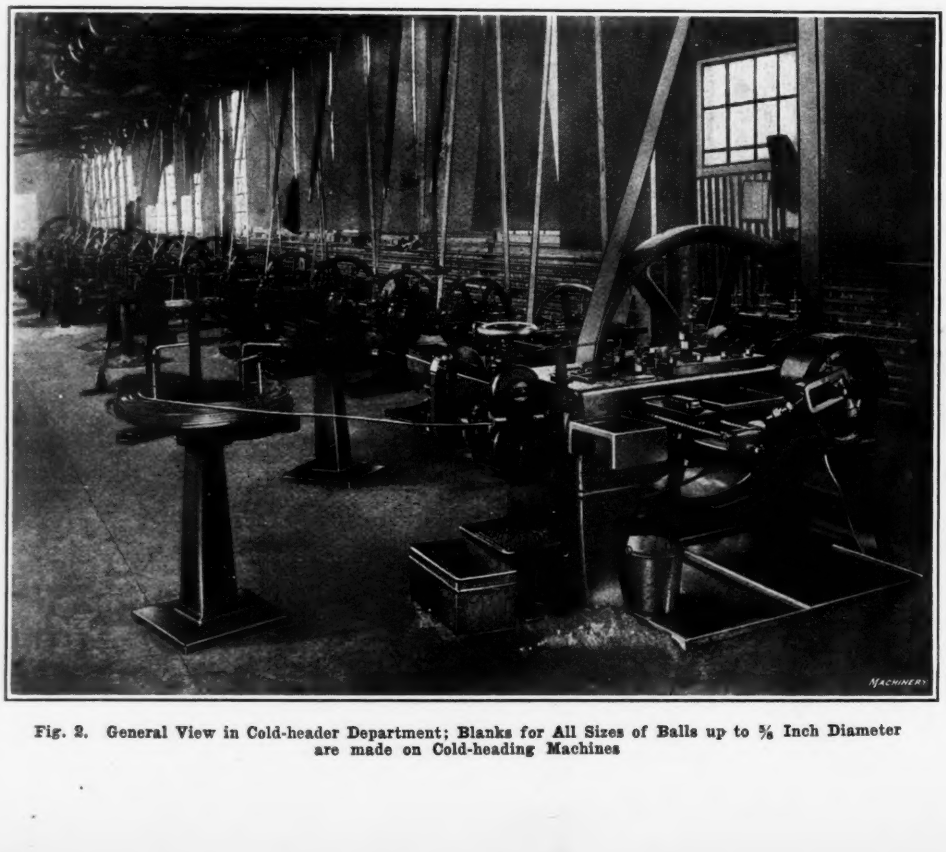


Fig. 2. General View in Cold-header Department; Blanks for All Sizes of Balls up to 5/8 Inch Diameter are made on Cold-heading Machines

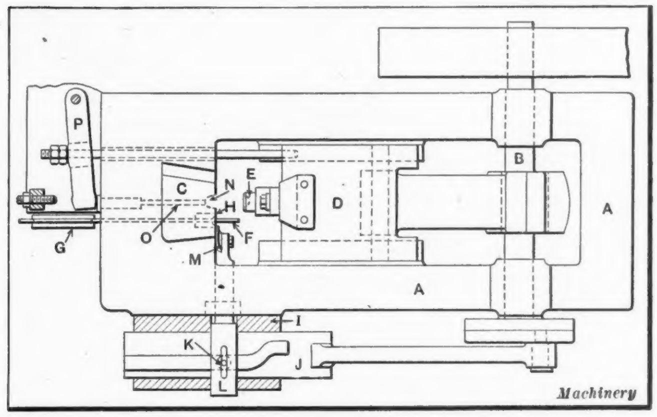



Fig. 3. Plan View of Cold-header Mechanism, illustrating Method of Operation

cut-off quill *H*. At the side of the machine is supported a bracket *I* in which slide *J* may be reciprocated by a crank motion from the main driving shaft. Slide *J* has a cam groove cut in it in which roll *K* is fitted; this roll is mounted on cross-slide *L*, so that a lateral motion is imparted to cut-off knife *M* located on the end of cutter-bar *L*.

A ratchet feed advances the wire through the cut-off quill until it comes into contact with a stop, which is not shown in the illustration. This stop checks forward motion of the stock when a sufficient length has passed the cut-off knife to produce a ball blank of the proper size. Cut-off knife *M* is advanced in the manner just described, severing the wire, but retaining it on the cut-off blade by means of a spring finger. Advance of the cut-off knife and wire slug is continued until the slug reaches a position directly in front of the opening in die *N*. Here it is held stationary long enough for punch *E* to begin to push the slug of metal into the die, at which time cut-off knife *M* retreats and allows punch *E* to continue its work by pushing the blank to the bottom of the die cavity. Wire slug *F*, when pushed into the die, is prevented from passing too far by a backing-pin *O*, and after the piece has been headed, this backing-pin is advanced by the ejecting mechanism operated by lever *P*, which also receives its motion from a crank at the side of the machine connected to the main driving shaft. In this way the ball blank is knocked out of the die and dropped

TABLE I. CAPACITIES OF COLD-HEADERS IN BALL BLANKS PER HOUR[1]

| No. of Cold-header | Capacity for Ball Blanks, Diameter in Inch | Production, Blanks per Hour | No. of Cold-header | Capacity for Ball Blanks, Diameter in Inch | Production, Blanks per Hour |
|---|---|---|---|---|---|
| 00 | 3/16 | 7800 | 2 | 3/8 | 6000 |
| 0 | 1/4 | 7675 | 3 | 1/2 | 4920 |
| 1 | 11/32 | 6250 | 5 | 5/8 | 4080 |

*Machinery*

[1] Note: Due to time lost in setting up, trouble with stock and breakdowns, the actual average rate of production is from 80 to 90 per cent of above values.

through an opening into a receptacle placed to receive it, this being clearly shown in Fig. 2. Table II gives the diameter of stock used in making blanks for several different sizes of balls, and is presented to show the enlargement that takes place during the heading operation. Various grades of steel have been used for making dies employed on the cold-headers, but the most satisfactory results have been obtained with the following grades: "Sanderson" or "Viking Special" made by the Crucible Steel Co. of America; "Intra" made by the Hermann Boker Co.; "Gyro" made by Braeburn Steel Co.; and tool steel made by William Jessop & Sons.

### Hot-forging Ball Blanks

It has previously been stated that blanks for balls exceeding 5/8 inch in diameter are hot-forged from straight bars, and in handling this work multiple dies are employed which produce strings of balls containing up to ten balls, according to the size. The stock is heated in "Frankfort" furnaces made by the Strong, Carlisle & Hammond Co. of Cleveland, Ohio; these are oil furnaces which are operated with oil at a pressure of 8 pounds per square inch, and air at a pressure of 2 pounds per square inch. Twelve bars are arranged in the furnace as shown in Fig. 5. The hammer-man takes out the bar at the left-hand side of the furnace, and after forging a string of balls at the end of this bar and cutting it up into individual ball blanks, returns the bar to the furnace at a point at the extreme right. In this way, the bars are used in rotation, which prevents any bar from be-

TABLE II. SIZE OF STOCK USED FOR MAKING BALLS ON COLD-HEADERS

| Diameter of Ball, Inch | Diameter of Stock, Inch | Diameter of Ball, Inch | Diameter of Stock, Inch |
|---|---|---|---|
| 1/8 | 0.095 | 9/32 | 0.200 |
| 5/32 | 0.120 | 5/16 | 0.225 |
| 3/16 | 0.145 | 3/8 | 0.265 |
| 7/32 | 0.165 | 7/16 | 0.312 |
| 1/4 | 0.180 | 1/2 | 0.355 |

*Machinery*

coming overheated. This is a matter of considerable importance, because the furnaces are maintained at a temperature somewhat in excess of 1800 degrees F. in order to provide for heating the stock as rapidly as may be necessary; but should it happen that steel was left in the furnace for an undue length of time, there would be danger of burning the steel.

The multiple forging dies are shown in detail in Fig. 7, in which it will be seen that each die opening is elliptical; the purpose of this is to provide a clearance space at each side into which excess metal may flow. It must be borne in mind, however, that while this illustration only shows four die openings, the number of openings runs up to ten, according to the size of ball blanks that are being forged. In the cross-sectional views, the dimensions of the die are indicated by letters, and in Table III are given diameter *A* of cherrying cutter, distance *B* between centers, and depth *C* to which the cherrying cutter is sunk in making the dies for three sizes of balls, and these data are presented to indicate how dimensions of the dies vary for different sizes of balls. The depth *D* of the gate between adjacent dies is a matter of considerable importance, because it determines the size of the neck between adjacent balls, which is depended upon to hold the string of balls together until they are sheared. Also, this depth must be regulated so that there is no ten-

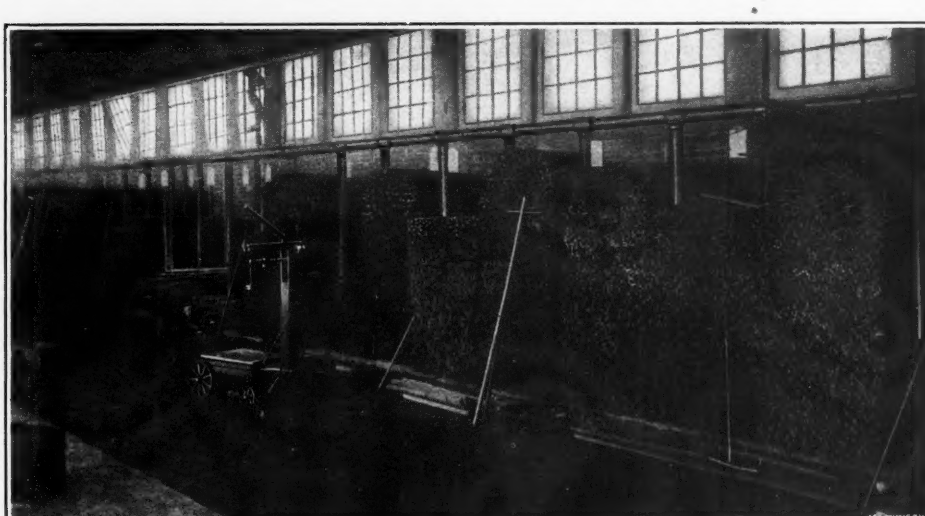


Fig. 4. View of Stock Racks in Hot-forging Department where Ball Blanks exceeding 5/8 Inch Diameter are made

dency to draw the stock adjacent to the neck and form a pipe in the ball blank, which would have a highly detrimental effect on its structure. A land of approximately one-third the diameter of the ball is provided for clearance at the bottom of the die and the upper die member. The dies are made from a special die steel made by the Ludlum Steel Co. of Watervliet, N. Y., or from "Firth-Sterling Special," made by the Firth-Sterling Steel Co., McKeesport, Pa. This is not an alloy steel, but a regular tool steel adapted for making hot-forging dies. In order to produce round balls in such dies, the bar is turned between each stroke of the hammer, which results in bringing the balls to a close approximation of the spherical form. Along one side of each die is a pipe with a number of holes drilled in it through which water flows onto the dies and work.

Fig. 5. "Frankfort" Oil-heated Furnaces made by Strong, Carlisle & Hammond Co., in which Bars are heated for Hot-forging Operation

In purchasing stock for the production of ball blanks for the hot-forging method, it is a matter of considerable importance to have all bars of the same length. This is due to the fact that when there is considerable variation in length, some bars will be used up before others, with the result that it is necessary to finish up a number of short pieces in the furnace before putting in an entire new charge. At the end of each bar there is left what is known as a "short end," and experience has shown that these short ends cannot be forged into ball blanks of the regular size, as they fail to fill out the dies properly. On this account, short ends are collected and forged into ball blanks of the next smaller size. By ordering stock in bars of a specified length, "short-ends" are eliminated.

After being forged, the hot string of balls is taken to punch presses made by the Ferracute Machine Co., Bridgeton, N. J., which are placed beside the Bradley helve hammers on which the forging operation is performed, the arrangement being clearly shown in Fig. 6. The punch presses are equipped with multiple shearing dies, which consist of a lower die member with holes of the same size as the balls and a multiple punch carried in the ram, one punch being in line with each opening in the die. The string of balls is dropped into place and the press tripped, resulting in pushing the balls through the holes in the die and leaving the scrap metal which is brushed off before the next operation is performed. The bar is then returned to the right-hand side of the heating furnace, as previously mentioned, and is moved to the left each time a heated bar is removed, until it reaches the extreme left ready for another string of balls to be forged from the heated metal at its end. Three sizes of helve hammers made by C. C. Bradley & Son, Inc., Syracuse, N. Y., are used for forging ball blanks, which have capacities for striking blows of 125, 150 and 300 pounds.

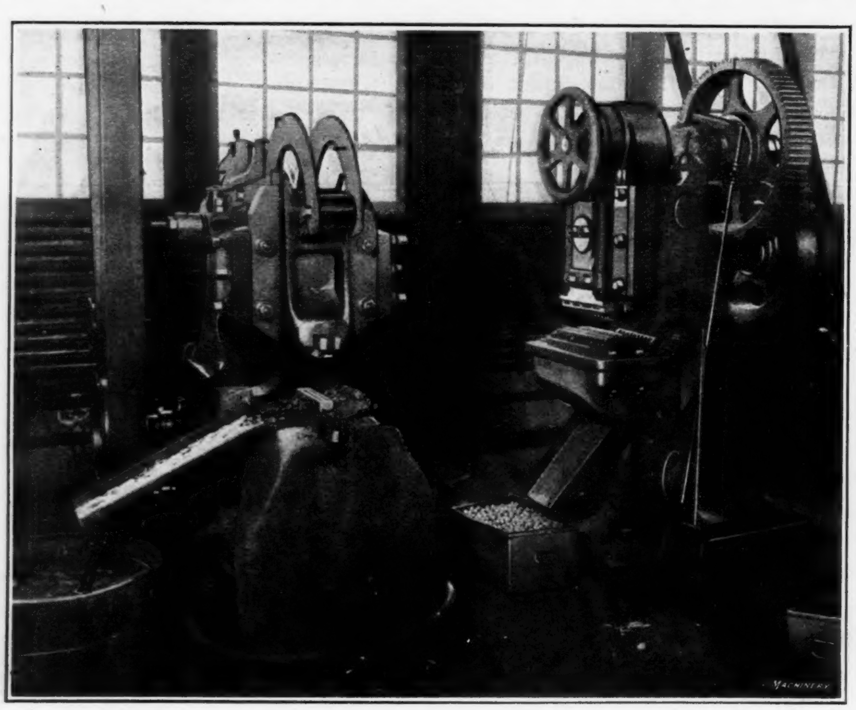


Fig. 6. C. C. Bradley Hammer and Ferracute Power Press in which a String of Ball Blanks is forged and cut up into Individual Balls

Fig. 8 shows the construction of shearing punches used for cutting up the string forgings into individual ball blanks. At *A* is shown the form of punch-holder used, which will be seen to consist of a cast-iron shoe with four set-screws for holding the punches. These are secured in a clamp *B* which is made by drilling holes of the proper size for the punch shanks in a block of the desired form and then sawing this block in half; the punches are then put in place and the entire clamp secured in punch-holder *A*. The diameter *C* of these punches is usually made about 1/8 inch less than the diameter of the balls in the string forging that is to be cut up. A plan view of the die is shown at *D*, and it will be evident that the spacing *E* between holes in this die is the same as the center distance between the die cavities in the forging die. Also a bridge is provided in the shearing die of sufficient depth to retain the neck left between adjacent ball blanks on the string forging while the balls are pushed through the die. After the shearing operation has been completed, the scrap metal is brushed off the shearing die before the next set of ball blanks is cut up.

It has been mentioned that balls ranging in size from 5/8 inch up to about 2 1/2 inches in diameter are made by forging strings of blanks according to the process which has just been described. In the case of the larger sizes of balls—from 2 5/8 to 4 inches in diameter—single blanks are usually forged under a steam hammer, making one blank at a time at the end of the bar. Slugs of the proper size are first cut off to the required length and both ends chamfered, the length of stock being determined by the weight of the finished balls after making a proper allowance for the material removed in finishing. These blanks are placed in the oil furnace and heated to a forging temperature; and each time a blank is removed to be forged a new slug of metal is put into the furnace in its place. Dies used for this kind of forging are of an entirely different form from those used in string forging; they are cupped out to the desired diameter, but are only turned to a depth of one-quarter the diameter of the ball to be forged and are not relieved. When the blank has been heated, the hammer-man

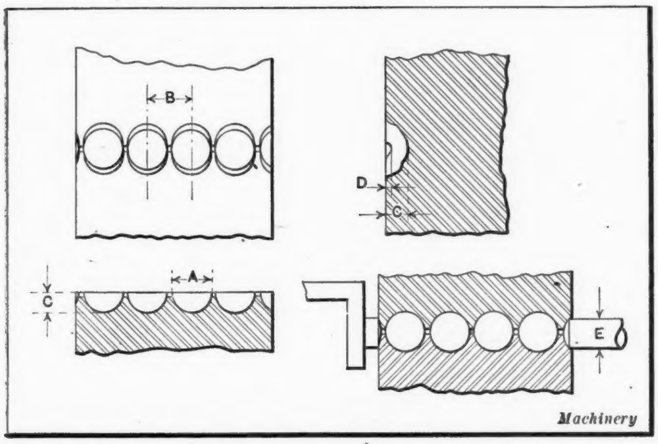



Fig. 7. Type of Die used for hot-forging Ball Blanks for Balls exceeding ⅝ Inch Diameter

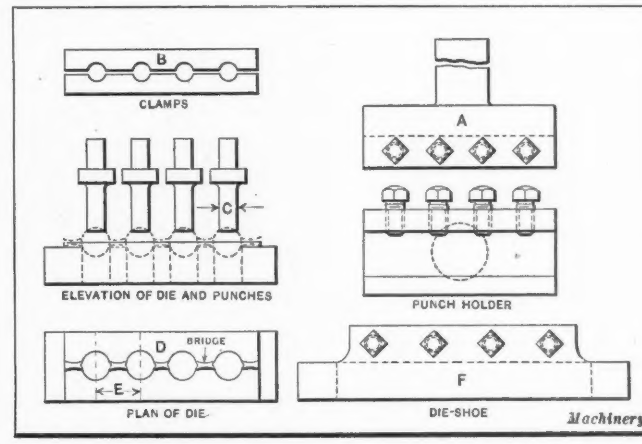



Fig. 8. Type of Die used for shearing String Forgings into Individual Ball Blanks

places it in the die and the hammer is worked very slowly until the blank begins to take a spherical shape, when quicker and heavier blows are struck. Owing to the shallowness of the die, the operator has ample room to turn the ball in all directions, and he can therefore produce an almost perfect sphere. Blanks up to 8 inches in diameter are forged without varying more than 0.005 inch from a true spherical form.

### Rough Dry-grinding

The method of making ball blanks varies according to their size, small blanks being made on cold-headers and large blanks forged from hot metal according to the methods which have just been described. After this preliminary work, all sizes of balls go through essentially the same treatment, certain minor modifications being made according to the quality of the balls; and the method of treatment may also vary somewhat in the case of balls of extremely large size. These modifications from standard practice will be taken up in detail.

TABLE III. DIMENSIONS OF HOT-FORGING DIES FOR BALL BLANKS

| Diameter of Ball, Inch | Diameter A of Die, Inch | Distance B between Centers, Inch | Depth C of Die, Inch | Depth D of Bridge, Inch | Diameter E of Stock, Inch |
|---|---|---|---|---|---|
| 3/4 | 0.775 | 0.910 | 0.387 | 0.065 | 0.609 |
| 7/8 | 0.905 | 1.060 | 0.452 | 0.065 | 0.719 |
| 1 | 1.035 | 1.210 | 0.517 | 0.075 | 0.813 |

*Machinery*

Blanks made by either the cold-heading or hot-forging process are first sent to the dry-grinding room, where they are subjected to a rough-grinding operation before going to the heat-treating department. This rough-grinding results in removing a considerable part of the surplus metal and bringing each ball to a much closer approximation of a truly spherical form than it is possible to obtain in forgings made by either of the methods that have been described. In the case of hot-forged ball blanks, this rough-grinding also removes the decarbonized steel from the surface of the blanks produced in forging.

An exception to the general method of procedure is made in the case of balls from 1/16 to 3/16 inch in diameter. Such balls are not dry-ground before being heat-treated, but they get a rough and a finish dry-grinding after being hardened.

Figs. 9 to 11, inclusive, show the type of machine on which the dry-grinding operation is performed, and the best idea of its construction and method of operation will be obtained

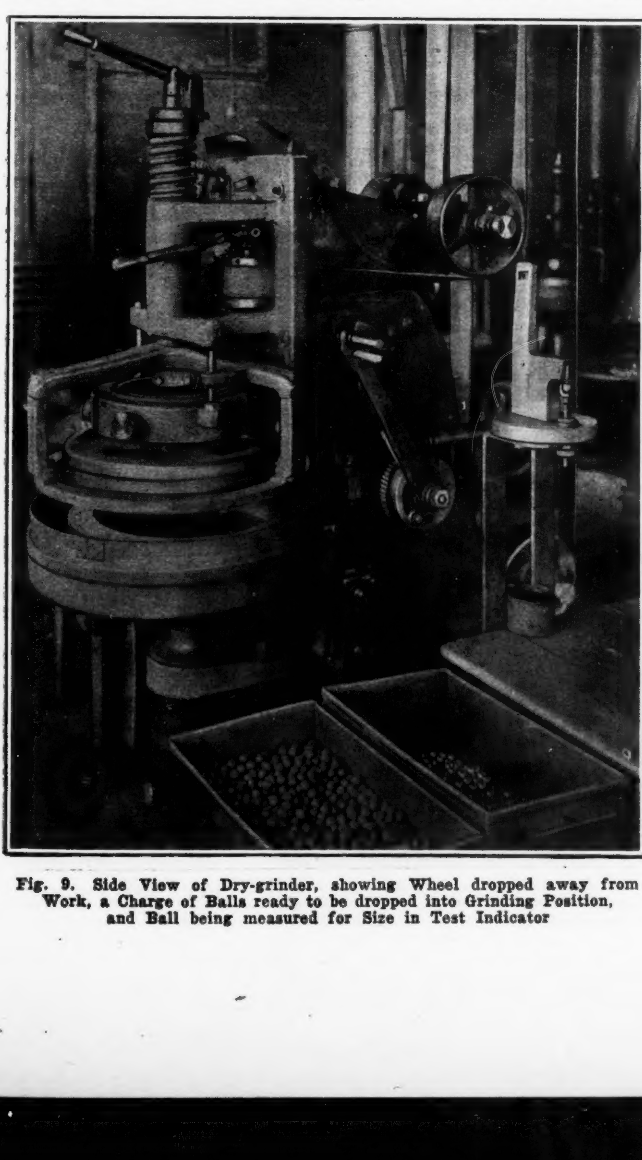


Fig. 9. Side View of Dry-grinder, showing Wheel dropped away from Work, a Charge of Balls ready to be dropped into Grinding Position, and Ball being measured for Size in Test Indicator

Fig. 10. Front View of Grinding Machine, showing Grinding Wheel raised to Operating Position and Tray of Ground Balls just removed from Machine; Balls seen in Ring are not in Grinding Position

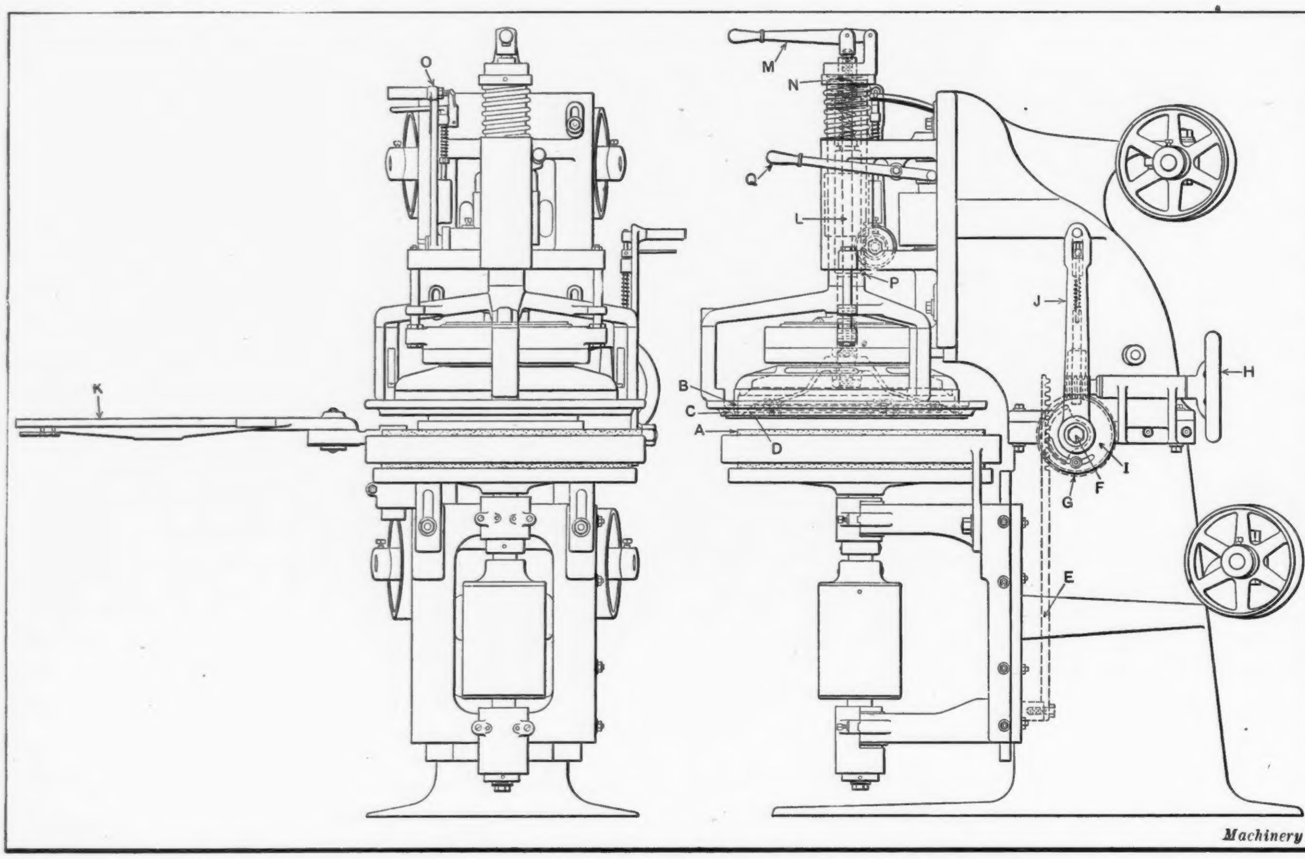



Fig. 11. Front and Side Views of Dry-grinding Machine, illustrating Principle of Operation

by reference to the two views shown in Fig. 11. The main parts of this machine consist of a carborundum grinding wheel *A* and an iron ring *B* which are driven in opposite directions. Two rings *C* and *D* are supported by spiders in such a way that there is a space between the beveled edges of the inner and outer rings sufficient to allow ball blanks that are to be ground to project through this space. In the side view of the machine illustrated in Fig. 11, these rings are shown with the wheel lowered, but when the machine is in operation the balls held between rings *C* and *D* are in contact with grinding wheel *A*; and ring *B* presses down and holds them against the grinding wheel. In order to provide for grinding the balls uniformly, the spindles on which grinding wheel *A* and driving ring *B* are carried are placed eccentric to each other, which results in giving the balls an oscillating motion in addition to their motion of rotation; and as a result of this combined movement all surfaces of the ball blanks are exposed to the action of the grinding wheel, which results in bringing them to a close approximation of the spherical form. The way in which the upper and lower spindles of the machine are driven is best illustrated in Fig. 9, which shows how open and crossed belts are brought to the machine pulleys from an overhead countershaft.

Probably the best way to describe the operation of one of these dry-grinders is to start at the point where a charge of ball blanks has been ground down to the required size and is to be removed from the machine. To provide for doing this, the head which supports grinding wheel *A* is carried on a slide on the base of the machine. Secured to the bottom of this slide is a rack *E* that meshes with a pinion at the end of cross-shaft *F*. Keyed to the opposite end of shaft *F* is a worm-wheel *G* that meshes with a worm actuated by hand-wheel *H* that provides fine adjustment. Secured to the bed of the machine is a disk *I*, and in order to drop grinding wheel *A* out of contact with the work held between rings *C* and *D*, the spring latch carried by lever *J* is withdrawn from a notch in disk *I* and the lever is moved to the left until the latch engages a stop notch in disk *I*, which limits the downward motion of the grinding wheel. It will be seen that sufficient clearance is now provided between grinding wheel *A* and

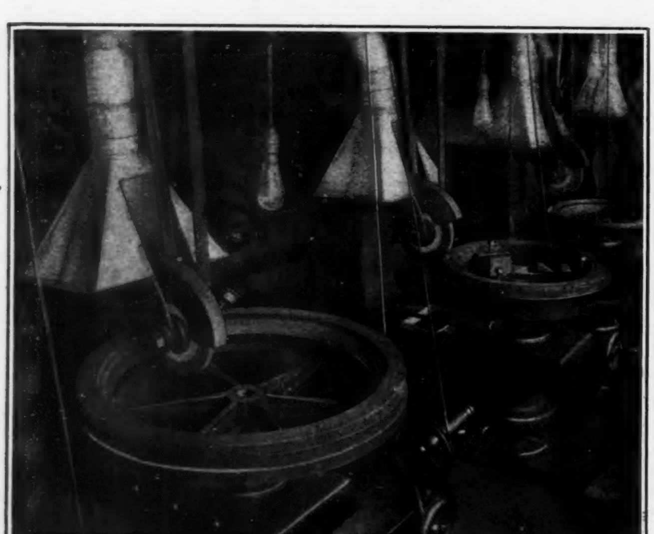



Fig. 12. Special Grinding Machines for grinding Rings shown at C and D in Fig. 11

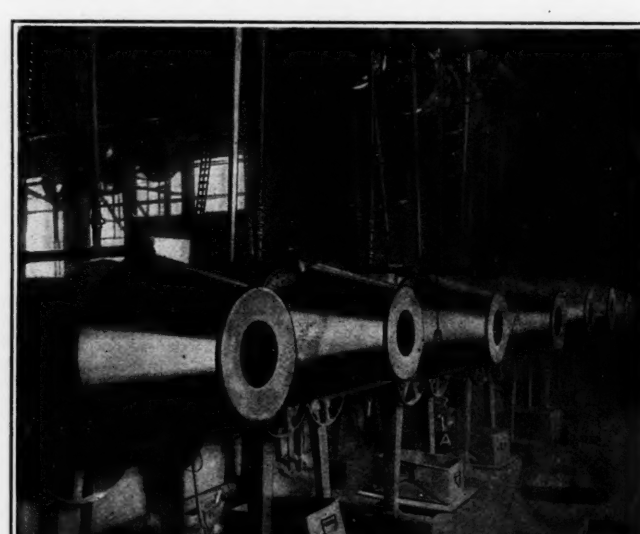



Fig. 13. Charging End of American Rotary Gas Furnaces in which Balls up to One Inch Diameter are heat-treated

rings $C$ and $D$ to enable tray $K$ to be swung into position to catch the balls when they are discharged from the holding rings.

It will be seen that inner ring $D$ is supported by a spider secured to the lower end of rod $L$, and in order to discharge the ground balls, ring $D$ is dropped by pushing down lever $M$. This drops the inner ring and allows the ground balls to fall into tray $K$. When lever $M$ is released, ring $D$ is returned to its original position by means of a compression spring $N$. During the time that the charge of balls in the machine is being ground, a fresh charge of blanks is placed in the space between driving ring $B$ and outer ring $C$; a few of these balls will be seen in position in Fig. 9. After the ground balls have been removed and inner ring $D$ has been returned to the position shown in Fig. 11, it is necessary to place the charge of new blanks in position to be ground. This is done by dropping both rings $C$ and $D$ sufficiently so that the balls held between outer ring $C$ and driving ring $B$ may drop into position, after which the two rings are returned to the location shown in Fig. 11. This result is accomplished by means of lever $O$ that is carried at the end of a cross-shaft which has a pinion at its right-hand end meshing with the rack $P$ cut in the sleeve that supports the spider on which outer ring $C$ is carried.

In order to drop a charge of balls into place, the spring latch carried by lever $O$ is released, and this lever is pulled forward which results in dropping both rings $C$ and $D$, due to the fact that rod $L$, supporting inner ring $D$, is pinned to the upper end of sleeve $P$, to which the outer ring is connected by means of the spider. When the balls have been dropped into position as indicated, grinding wheel $A$ is raised into contact with the work by raising lever $J$. Rings $C$ and $D$ are ground to a smooth surface and fine edge in order that the balls may run freely and reach through the space to come into contact with the grinding wheel $A$. This is done on special grinding machines, the method of grinding the inner and outer rings being clearly illustrated in Fig. 12. Lever $Q$ at the front of the grinding machine operates a clutch that provides for starting or stopping the machine. It will be seen from Figs. 9 and 10 that the grinders are provided with an exhaust system to carry away the dust of the wheel.

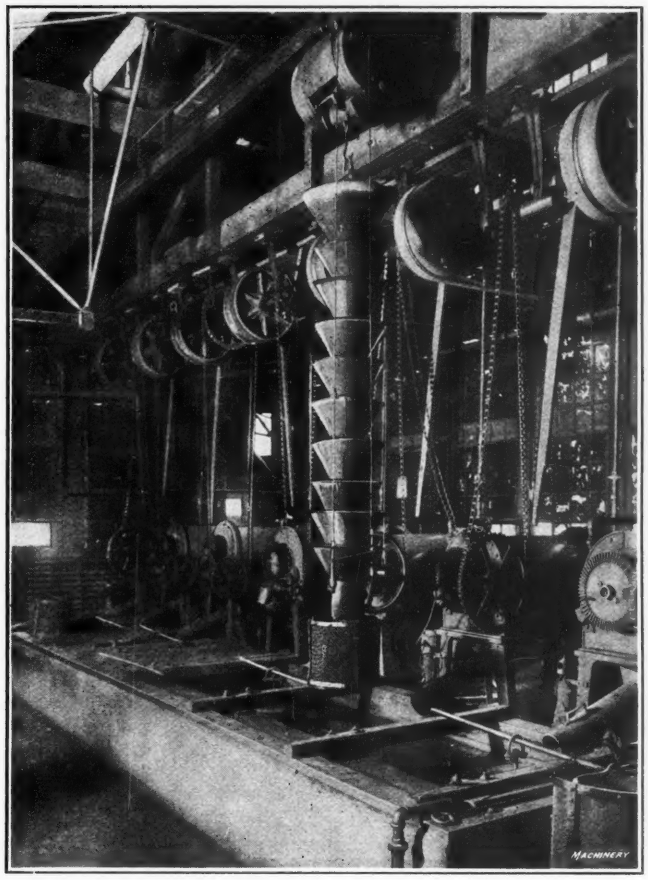



Fig. 14. Discharge End of American Rotary Gas Furnaces, showing Quenching Tanks and Deflector through which Balls are delivered to Baskets at Bottom of Tanks

### Heat-treatment

During the process of making the steel for the balls and in forging and rough-grinding the ball blanks made from this steel, severe internal strains are likely to be set up in the metal that would often be of sufficient magnitude to cause the balls to be broken when subjected to only a small part of their rated load carrying capacity. Trouble from this source must be eliminated, and this is done by subjecting the balls to a preliminary annealing operation in rotary gas furnaces made by the American Gas Furnace Co. of Elizabethport, N. J., before the final hardening operation. The same type of furnace is used for the annealing and hardening operations, but for the former the delivery chute on the furnace is arranged to discharge the balls into pans, as shown at $A$ in Fig. 13, while for the latter the balls are discharged into a quenching tank, as indicated in Fig. 14. The form of retort used in these American gas furnaces is shown in Fig. 16, and it will be seen to have a spiral path through which the balls pass as the retort is revolved. At the loading end of each furnace there is a hopper that is kept filled with ball blanks, and the retort draws blanks from this hopper and passes them through the furnace at such a rate that the steel is heated to the desired temperature when the balls are discharged. For annealing, a temperature of 1300 degrees F. is employed, and for hardening the balls are raised to a temperature of from 1425 to 1475 degrees F. according to the size and the composition of the steel. Pyrometers made by the Hoskins Mfg. Co. of Detroit, Mich., are used to determine the temperature of each furnace.

### Quenching the Steel Balls

It has been mentioned that the same type of furnace is used for both the annealing and hardening operations, the only change being to place the tube so that the ball blanks are discharged into a pan in the case of annealing, and into the quenching tank in the case of the hardening operation. The retorts used in the furnaces were formerly made of cast iron, and great trouble was experienced through their destruction after they

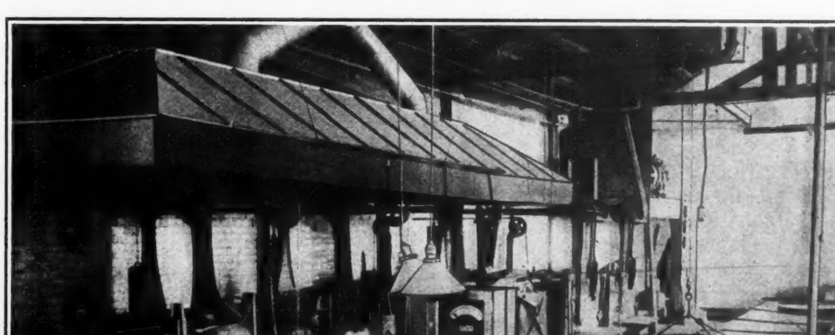



Fig. 15. "Frankfort" Oil Furnaces for Use in heat-treating Balls over One Inch Diameter, and Quenching Tank in which these Balls are hardened. Note Hoskins Pyrometer for showing Temperature of Furnaces

had been in service a short time. This trouble has been overcome by substituting "Nichrome" in place of cast iron, and retorts made of this material last for a long time before they are burned out.

In hardening there is a difference of practice according to the size of the balls, those of 5/16 inch diameter and less being quenched in oil while balls of larger size are quenched in water. Balls made of some grades of steel are quenched in pure water and others are quenched in brine. In all cases the quenching tanks are provided with a device of the form shown in Fig. 14, which consists of a series of conical sheet metal deflectors through which the balls pass before reaching the wire mesh basket at the bottom of the tank. The purpose of these sheet metal cones is to deflect the course of the balls so that they follow a winding path and are completely cooled before reaching the bottom of the tank. One complete furnace charge can be run into one of these wire baskets and when this is filled, the entire outfit is lifted out of the tank by means of an electric hoist as shown, and the balls are then removed from the basket. The depth of the quenching tank is about 14 feet. Rotary furnaces are used for annealing and hardening the smaller sizes of balls, and in the case of balls one inch in diameter and over, "Frankfort" oil furnaces are employed, into which the balls are introduced on trays as shown in Fig. 15. When the balls are heated to the proper temperature, these trays are withdrawn and the balls are dumped into the quenching tanks provided with the sheet metal cones described. The reason for quenching small balls in oil and large balls in water is that the oil does not absorb the heat as rapidly as the water, and in the case of very small balls, the shock of dropping them into water would result in strains so great that many balls would either be cracked or broken, and the strength of those balls in which there were no visible defects would be seriously impaired. In the case of large balls, there is sufficient heat to prevent trouble from this cause. From time to time sample balls are tested by breaking them on an anvil and examining the structure of the steel to make sure that the heat-treatment is producing the desired results. Provision must be made for preventing overheating of the oil or water in the quenching baths, and this is done by having a circulating system through which the oil or water passes into a reservoir outside the building and then through a coil in this reservoir and back to the tank. In this way the contents of the quenching tank are kept in continual circulation, preventing overheating.

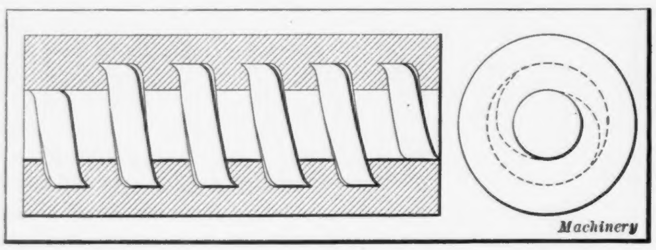



Fig. 16. Cross-sectional View of "Nichrome" Retort used in Rotary Gas Furnaces

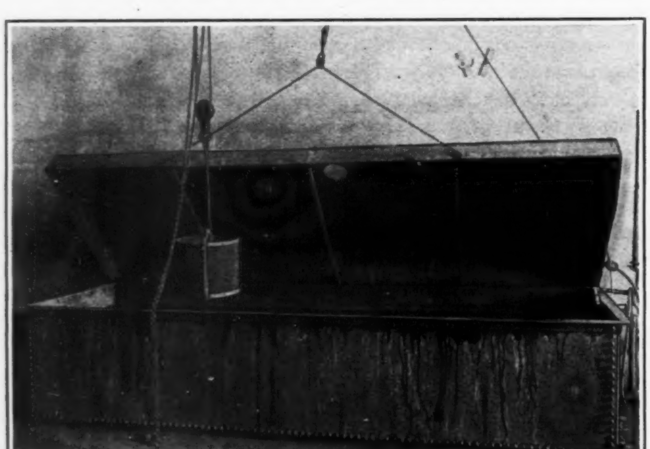



Fig. 17. Water Bath in which Severe Strains are removed from Balls quenched in Water by subjecting them to Temperature of Boiling Water for Two Hours. This Treatment also enables Balls to dry rapidly and prevents Rusting

### Water-anneal to Prevent Excessive Strain

During the process of hardening, internal strains are set up in the balls, and it is necessary, of course, to remove these strains. This is done by subjecting them to what is known as a "water-anneal," consisting of immersing wire baskets containing the balls in a tank of boiling water for two hours, which is said to remove excessive strains. The equipment used for this purpose is shown in Fig. 17. This practice of "water-annealing" is only followed in the case of balls that are hardened by quenching them in water; for small balls quenched in oil, the "water-anneal" is unnecessary. In addition to annealing, this treatment in hot water prevents the balls from rusting because they dry off more quickly than if they were quenched in cold water.

### Finished Dry-grinding

After being hardened, the balls are sent back to the dry-grinding room, where they are subjected to what is known as a finished dry-grinding operation. This is the same as the rough dry-grinding that the balls receive before hardening, except that it is done with a finer wheel which results in removing the scale produced in hardening and also reducing their diameters a little closer to the finished size; the finished dry-grinding also serves to remove any distortion which may have been introduced during the process of heat-treatment. For the rough-grinding operation, wheels of No. 40 grit are employed. On finish-grinding, the grit of the wheel varies according to the size of the balls. Wheels of No. 60 grit are used for all balls exceeding 5/16 inch in diameter, while for smaller balls wheels of 90 or 100 grit are employed. In all cases the machines are driven at the required number of revolutions per minute to give a surface speed of 4500 to 5000 feet per minute at the point where the ring wheel engages the balls.

The second installment of this article, which will appear in the April number of MACHINERY, will take up the process of ball manufacture at the time that the finished dry-ground balls are delivered to the tumbling department. This installment of the article will describe in detail the operations of tumbling or "oil-rolling," oil-grinding, burnishing, drying, polishing, inspecting and packing the finished balls ready for shipment.

* * *

## BRAKE AND CLUTCH LINING

Fabric brake and clutch lining is made principally of cotton or asbestos, according to a paper read before the Association of Mining Electrical Engineers of Leeds, England, by J. Oswald of Glasgow. The cotton fabric has the higher coefficient of friction, 0.5 to 0.7, and is capable of absorbing much greater work, in foot-pounds per square inch, at a given pressure than the asbestos. The coefficient of friction rises with increased temperature and is practically unaffected by oil or water. The choice between cotton and asbestos is determined partly by the amount of heat that is likely to be generated; in all cases where 400 degrees F. is likely to be exceeded, asbestos should be used. Its coefficient of friction is 0.3. On account of its nature, the asbestos fabric is usually reinforced with brass wire, which makes it more expensive than cotton. Failures with fabric linings are due to the use of the wrong material, to failure to keep the fabric face clear of the opposing face when brakes are out of action, to failure to insure that the fabric is kept well home when applied, incorrect fixing of linings to the engaging media, and expecting too much from brakes that have been under-dimensioned by the makers for the duties they must perform.

* * *

It is estimated that the available water power in European Russia, including Finland, the Ural district and the Caucasus, is 10,000,000 kilowatts, or over 13,000,000 horsepower. Only about one-fortieth of this is now being utilized.

# Successful Shrapnel Manufacture[1]

by Chester L. Lucas[2]

**Much has been said about the shortcomings of a few of the hundreds of American concerns that undertook munitions manufacture during the past two years and were unsuccessful in carrying out their contracts. But there is another side to the story, as is exemplified by those who have been highly successful. How the Westinghouse Air Brake Co. organized, equipped and managed for the production of 1,250,000 rounds of three-inch shrapnel and 1,500,000 additional time fuses, making a total of 5,250,000 parts, is described here. This article on management with horse sense is presented in the hope that the ideas will be of service to those who may be suddenly confronted with similar shell manufacturing problems.**

THE problem of equipping for munitions manufacturing is in no way different from that of equipping for the manufacture of motor cars, cream separators, pencil sharpeners or any one of a hundred and one other products required in large quantities, unless it be that munitions work is attended by more or less rush and frenzy due to the nature of the product. The fact that the general public is greatly interested in any munitions activities, even to the point of inquisitiveness, helps to add to the general excitement. Shell manufacture, for instance, presents few really mechanical operations. The measure of success of such an enterprise is largely fixed, as in any other manufacturing proposition, by the way in which the working organization is perfected, the plant equipped and the work planned. The trouble with the shell manufacturers who have not been oversuccessful has seldom been in their mechanical practice, but in the personnel of the organization, the selection of the equipment and the method of procedure from the standpoint of management. In manufacturing any new product, there are certain preliminary stages that must be gone through if success is to be attained. The shell-making concerns who have succeeded have recognized this principle and have patiently gone through this period before attempting actual manufacture. The temptation to start prematurely is great, and is often increased by the pressure of the financial interests behind the organization. These men naturally are impatient to see things moving, even though they do not understand the mechanical difficulties to be surmounted. Moreover, the desire to "make a showing" and the insistent calls for deliveries augment the force that induces some managers to start manufacturing before they really know what they are doing. As in all such cases this premature start serves to complicate matters, manufacturing methods have to be changed as unsolved difficulties are encountered, resulting in much work having to be done over and a general upsetting of plans and schedules.

The keynote to the whole situation is found in the old adage, "First be sure you're right—then go ahead." There is nothing new in this principle, but it has proved to be true, as never before, by the lessons learned in the shell-making industry.

In view of these pitfalls to be avoided, it is gratifying that many of the concerns who took on contracts for munitions, especially shells, went at things in the right way, organized and equipped along the right lines and filled their contracts satisfactorily and on time. Much has been published about the mechanical operations of these plants, but little has been written of the details of organization and equipment for the work. While it is hoped that the demand for shells will not be increased, no one can predict how soon thousands of American manufacturers may be called upon to make shells for their own government. In the successfully handled contract described below may be found guiding points worth remembering.

Prominent among those who were successful in completing their shell contracts on time, is the Westinghouse Air Brake Co. of Wilmerding, Pa. The company's first order called for 1,250,000 complete rounds of 3-inch shrapnel, which meant that 1,250,000 each of brass cartridge cases, steel shells and time fuses had to be produced. The work was finished well within the time specified in the contract. Following this contract was another for 1,500,000 time fuses and this work was completed February 1, 1917. Two months and a half after signing the first contract the organization had been perfected, the equipment installed and production had commenced. At the height of the work 10,000 shells, fuses and cartridge cases were produced daily by the 1500 men on the day shift and the 1000 men on the night shift. Through the courtesy of A. L. Humphrey, vice-president and general manager, and O. W. Buenting, general factory manager of the company, these details of procedure in organizing and equipping for this work are presented.

One reason for the success of the work in this plant was the limiting of the work undertaken to just one size of shell. Many less successful shell contractors befuddled their work at the start by taking small quantities of several different sizes of shells. Each additional size increased the prospects for trouble many-fold.

### Planning the First Steps

As soon as a definite decision was reached on what was to be manufactured, a conference was called of the mechanical heads of departments and engineers, and suggestions and ideas were asked for. After a day or two of deliberation another conference was called and these ideas and suggestions

[1] For information previously published in MACHINERY on the organization and management of munitions plants, see "What is the Matter with the Munitions Makers?", December, 1916.
[2] Associate Editor of MACHINERY.

"The machine tool builders and their salesmen were of great assistance in advancing good ideas"

were presented. With the suggestions as a basis, definite plans were adopted, and active preparation for the work began. The final plans were no one man's ideas but were a combination of ideas representing the best mechanical and executive brains in the organization.

Segregation of the shell work was an important factor in the success of the work. All the shell work was kept in one building of the plant and three distinct departments were organized to take care of the cartridge cases, shrapnel shells, and time fuses. A tool-room was provided for each department to make the tools and keep them in condition. In this way the toolmakers became specialists in the particular lines of tools for which they were responsible.

#### Personnel of the Shell-making Organization

An important factor that counted for much at this plant and one that some less successful concerns lost sight of, was the personnel of the organization. No new superintendents or foremen were engaged for the shell work. From the already successful organization making air brake apparatus, the new organization drew a few foremen, a large number of assistant foremen and leading hands, and took them into the shell-making department. The other way of building a body of shell-making executives would have been to hire men from outside. Such men would have been hard to get, even at high wages, because of the obviously temporary character of the work, and when secured, they would have been untried and of unknown ability. The company's own foremen were of known ability, and after the contract was filled would be even more valuable on their old jobs. The positions left vacant were filled by moving men upward in the line of promotion. As far as possible, the most important foremen were retained in the permanent organization to insure that the air brake production would not be interfered with.

Contrasted with this was the method of getting together the force of operators necessary to run the machines and work on the shell job. These were almost all new men hired through the employment office. If men from the air brake plant asked to go on the shell work they were permitted to do so, but were told that the job was temporary and if they went on the shell work they would have to take chances on re-employment after the work was over. As a matter of fact, not over 8 or 10 per cent of the old employes were transferred to the shell department. This number was just enough to give stability to the green men on the job.

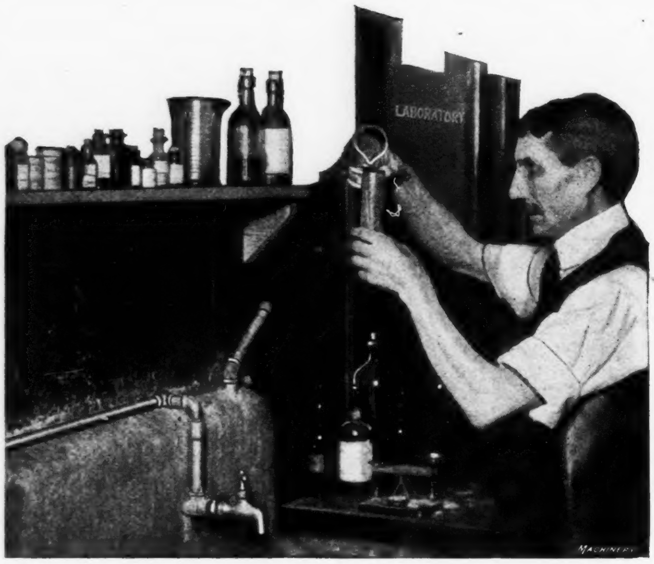
On the fuse work, it was found that girls could be employed to advantage on many operations, such as burring, lapping, inspecting and assembling, because of their ability to do repetition work without tiring and their deftness on these small operations.

#### Equipping for the Work

The planning of the sequence of operations, the methods of tooling and the nature of the equipment was similar in most respects to that of many other shell-making concerns, and was directed by the general superintendent, assisted by the engineers and the designers on the staff. When getting ready for the work, many other shell manufacturing concerns were visited, and all the assistance possible was gleaned from every available source.

The machine tool builders and their salesmen were of great assistance in advancing good ideas for equipment, tooling, etc. Their experience on similar propositions in different parts of the country had given them an insight into the work that was not to be neglected. Of course the salesmen were looking for sales, but their assistance was gladly accepted if it appeared that their machines were best suited to the work, everything considered. No machinery was taken from the air brake plant; every machine used on the shell job was new.

In buying the machinery and other equipment for handling the shell work, two important points were constantly borne in mind. The first was to select only such machinery as would be useful in regular lines of manufacture after the shell business had passed. Of course, for operations like graduating or milling powder train grooves, special machinery was needed, but for turning, drawing and similar machining operations, standard machinery was used. Owing to this policy, the company is not now in possession of a lot of unsalable machinery. Already a large percentage of the shell-making machines has been absorbed into the air brake plant, and the absorption process is still going on.




"The metallurgists were kept busy determining what grades of metal should be used"

The second point borne in mind in buying equipment was to select as far as possible only such machinery as would do the work when run by operators of average intelligence. Skilled machine men were scarce; therefore the "brains were kept in the machines" as far as possible. This means that the simplest machines were not purchased, as they would have required skilled men to get exact duplication of the work. The machines selected

"—went over the specifications for the various parts, word for word, making sure that everything was perfectly plain"

were, as far as possible, of the automatic or semi-automatic type, which when once set up would produce accurate work in the hands of the average run of unskilled labor such as applied for positions every day.

The argument was presented by some manufacturers of single-purpose machines that one good sized shell contract would overwork any machine equipment to the extent that the machines would be "shot to pieces" by the time the contract had been completed. It was claimed that the wear and tear that the machines would receive at the hands of green operators, coupled with the pace that would be followed in getting out the order would wreck any machine tool. For these reasons, it was argued, high-class all-around machinery should not be bought, since it would be ready for the scrap heap after its shell-making season.

The fallacy of this argument is well demonstrated by the condition of the machines used on this contract. Machines pulled down for examination were found in good condition, in spite of the year-and-a-half of day and night service by operators taken from steel mills, farms and wherever else they could be found. This machinery was more costly than single-purpose machines, but the difference was more than made up by the reduction in the labor cost of producing the shells. Out of the hundreds of thousands of dollars worth of machinery bought for this contract not over 10 per cent is of the special or single-purpose class to the extent that it cannot be used in any other line of manufacturing. At least 25 per cent of the machinery has been absorbed in the railroad equipment plant and more is being taken in as needed.

"On the fuse work it was found that girls could be employed to advantage"


"Every shipment of material was held until lot samples could be taken and tested"

### Chief Chemist and his Important Work

While the mechanical engineers were determining what machinery should be used and what tooling methods should be adopted for producing the various shell parts, the chief chemist and his assistants were also busy—fifteen hours a day. First, and one of the most important of the steps taken, was the checking of the specifications. These were studied by the chief chemist in person, who went over the specifications for the various parts, word for word, making sure that everything was perfectly plain. In many cases where the specifications were capable of being read in two ways, the obscure point was clarified by consultation with the inspectors. In some cases also the specifications stated that work should be done "with sufficient accuracy" or "in a suitable manner." The chief chemist made it his business to find out just what was meant by these phrases so that there would be no trouble when manufacturing actually commenced. Too much cannot be said of the wisdom of this preliminary work, as much trouble was thereby avoided, and when actual manufacturing commenced there were no annoying delays in finding out what had to be done to meet the requirements of the specifications.

The metallurgists were kept busy determining what grades of metal should be used, and samples from the mills were tested and the sources of supply thus fixed upon. In this connection, great care was taken that for every class of material two or more sources of supply were maintained. In this way production hold-ups from delayed shipments and shortage of stock were averted. Every shipment of material was held until lot samples could be taken and tested. When found O. K.—and not before—the shipment was allowed to enter the plant and go into production.

The testing of the shell steel and the determination of the necessary heat-treatments were important preliminaries of the metallurgical work. Tensile strength tests had to be made, and after the desired results were obtained, the exact procedure to be followed in heat-treating was arbitrarily laid down. The drawing brass for the cartridge cases was experimented with, actual tests in drawing were made and the most satisfactory annealing temperatures were selected. It will thus be seen that these important points were all settled before the time for actual shell-making had arrived.

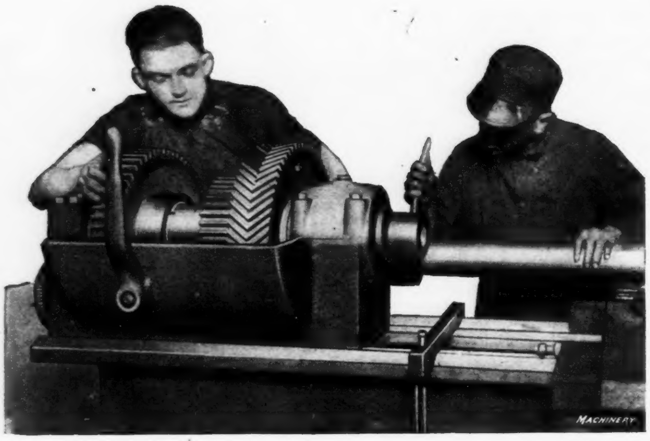
While actual manufacturing was in progress the chief chemist still had plenty to do. Branch laboratories were installed at the points where help in maintaining correct conditions would be required, notably in the heat-treating and cartridge case departments. The assistants in these departments spent their time in making tests to assure that all was going well and in many cases went about looking for trouble. It was found, for instance, that oftentimes brass from two different shipments, although agreeing in analysis would not act alike in turning. Worked in the same machine with the same set of tools, one bar of brass would produce parts of slightly greater dimensions than another. After careful investigation it was found that the fault lay in the reducing treatment that the brass had received at the mill. When the brass was reduced too much between annealings it took on a harder temper and resisted the cutting tools to a greater degree, and the tools did not "cut to size." It then became necessary to take the heat-treatment up with the brass mill which thereupon adopted more exact methods in reducing and annealing so that the shipments of brass would be alike in temper. Causes

"—every shell was scleroscoped before and after heat-treatment"

of trouble like this sometimes took longer to discover than to correct, but their elimination formed an important part of the metallurgist's duties, and contributed materially to the success of the shell work.

### Keeping Peace with the Inspectors

Absence of friction between the inspectors and the production force was a noticeable feature of the work on the shell contracts at this plant. One reason for this was the definite instructions issued to the foreman of each department of the shell plant to meet all the inspectors' requirements—and to the inspectors' satisfaction. There was no room for argument, because in this shell plant "the inspector was always right." In exceptional cases, where the inspectors' requirements were deemed to be too severe, the matter was taken up by the factory manager and the inspector-in-chief, and quickly and amicably settled.


"Machines pulled down for examination were found in good condition in spite of the year-and-a-half of day and night service"

Over all the shell work was the chief inspector of the plant, who had assistants in every department. The limits for each dimension of all shell parts were arbitrarily set by the specifications of the contract. The limits set by the shell plant inspectors were kept well within those called for by the specifications, so that if the shell parts were made to the limits called for by the gages of the plant inspectors they would surely pass the more liberal gages of the final inspection.

Good gages and their maintenance were a great aid to successful work. These gages were made in the tool-rooms adjacent to the shell, case and fuse production departments, so that the toolmakers on each job became proficient in making the few types of gages needed for that particular department.

One of the pitfalls into which many shell contractors fell was in heat-treating. This trouble was partly due to the attempt to do the work without the necessary precautions being taken. In this plant, the experiments conducted by the metallurgists before production started helped to solve this problem. This preliminary work resulted in determining the exact heat-treatments before the first shell forging reached the plant. After production started, every shell was scleroscoped before and after heat-treatment. Some contractors have endeavored to "get by" with a scleroscope test on but one or two shells from each heat-treated lot, but the many poor shells that escaped undetected caused a great deal of trouble. Owing to the extreme care used in all inspection, and especially to the careful heat-treatment inspection, almost no shells were rejected from the entire lot of 1,250,000.

### Hiring and Paying the Operators

When the shell plant was completely equipped and ready for operation, the machine operators and other employes needed on the work were hired in especially for this job, as before stated. A small percentage of the regular working force of the railroad equipment plant was transferred to the shell plant merely for the purpose of giving stability to the working force. The machinery was new, the operations unfamiliar and the men green; therefore, at first the pay was by the day. As soon as practicable, however, piecework prices were set, based on the showing made while on day work, and the prices were maintained without change until the contract was completed. These prices were set high enough to enable the operators to make from forty to forty-five cents an hour on the average; in some cases proficient workers were able to exceed this average considerably. The piecework prices were not changed unless the methods of performing the work were changed. This positive setting of the prices and their maintenance were made possible because the start on day work afforded the opportunity to study the feeds, speeds and productions.

Many of the machine operators, especially at the start of piecework, had great ambition to turn out abnormal quantities of work and increase their earnings. The result was inevitable—the quality of the work suffered. After a few of these performances, the foremen were given instructions to check immediately a man who tried "to cut loose" at the expense of the quality of the work.

Considerable trouble was experienced in getting new men "down to earth" because the prevailing reports about shell-making wages in general brought applicants who thought that ten to fifteen dollars a day should be their average earnings. As a matter of fact, the piecework prices were set high enough to allow inexperienced men to make higher wages than they had ever earned before.

### Shell Making without Impairing Air Brake Production

While this production of 10,000 complete rounds of shrapnel a day was going on, the railway air brake plant had to be maintained without sacrifice. The fundamental policy of keeping the shell work entirely separate and as far removed as possible from the railroad air brake department proved most wise. Another important point was that in selecting the organization to be used on shell work, the foremen and other executives were taken from such positions on the air brake work as would interfere the least with production. The foremen of the principal departments were undisturbed with few exceptions. By promoting many of the under-foremen and leading hands to positions of responsibility on the shell work, good results were secured, because these men were ambitious to make good in their new positions of authority and exerted every effort to be successful. The shell work was begun at a time when the railroad business was dull, and it seemed a mockery of fate that as soon as the shell work was well started the air brake business rapidly increased, and when the shell work was at its height the air brake plant was also busy. This shell contract, totaling 3,750,000 3-inch shells, cartridge cases and fuses, was completed well within the contract time of one year. The additional contract for 1,500,000 time fuses was also put through within the contract time of six months, and the work was carried on without allowing the air brake production to fall behind.


"—this shell contract . . . was completed well within . . . one year"

## INDUSTRIAL PREPAREDNESS

BY A. B. HAZZARD[1]

There seem to be varied and diverse opinions as to the probability of the United States being able to make a sufficient quantity of munitions in the event of war. In a recent issue of the Philadelphia *Evening Telegraph* of January 27, Howard E. Coffin of the Council of National Defense, states that it would take from five to thirty years to properly equip plants and manufacture munitions in sufficient quantities to supply our army and navy in case of trouble. In considering this statement it is well to remember that Mr. Coffin, himself has developed a large and extensive automobile plant in less than ten years and is considered one of the most rapid producers of automobiles in this country. We might also point out the accomplishments of the Ford plant, in Detroit, which in less than fifteen years has done far more difficult work than the production of munitions, both as regards accuracy, refinement and volume of production. It is true that there have been a number of failures of munition manufacturers, but they were few in comparison with the number who were successful.

I stated in an article published in MACHINERY, July, 1916, that there were in the United States at that time sufficient plants equipped with machinery that could be changed over to manufacture shells to turn out in thirty days 300,000 shells a day. That was a conservative statement. After carefully going over the conditions, I believe it would be possible to make half a million shells per day in this country with the equipment in use at the present time. I know of an instance where, in five months, a plant was equipped with shell-making machinery and turned out 3000 9.2-inch English shells daily. It should be possible to machine an armor-piercing shell of the same corresponding size in less time than a British high-explosive shell.

As for equipment, conditions are now perfected to such an extent that machines can be made in six or seven hours that are capable of performing both the internal and external machining operations necessary to finish shrapnel shells. It would take longer to ship the machines from the factory to the plant than it actually takes to build them. This is the work of but one concern. There are numerous other machine tool builders prepared to turn out large quantities of tools for the machining of shells. The smaller shells, six inches in diameter or less, could be machined from bar stock in far less time than they could be made from forgings, which is the practice now used for manufacturing shells for the Allies. There are a half dozen or more mills that could turn out bar stock and start shipment within four or five days from the receipt of orders. In summing up the conditions that obtain at the present time there is no reason why, within thirty days, we could not start shipment of the finished product in large quantities.

It is a fact that automobile manufacturers possess a limited number of machine tools capable of making munitions. A few scattered automatic machines in the different plants could probably be put together in an emergency and a large quantity of small shells produced. However, they would not be likely to be used, as these automatic machines have been improved to a great extent for making munitions and would be far more efficient than those now running in the average motor car plant.

As for high-explosive shells, together with the cases, primers, time fuses, etc., there are a number of manufacturers who are engaged in this line of work and would require but minor changes to modify their equipment for turning out these shells according to the government specifications. It might be stated further that there are numerous plants prepared to make different size shells and parts, all of which are, no doubt, listed and in the hands of the Council of Defense. As a matter of fact in from three to six weeks, shipment could be made in quantities far greater than would be needed by the army in case of an emergency.

There are other materials probably just as important that should be seriously considered by the Council of Defense. It would be advantageous to publish specifications in detail of the different commodities required by both the army and navy. This would educate the manufacturers in different lines, and would help them to prepare for the future. Then, again, this is the best time for standardizing such commodities as can be made exclusively in this country. This, in itself, would be a big saving of time. For instance, if manufacturers of trucks or other articles knew of a certain standard specification it would greatly facilitate their work. There is no reason to make a secret of these things, as there is no particular benefit to be derived from this policy. We have specifications of a great many articles used during the present war by the other countries that have given us valuable information and have done them no harm.

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* * *

## TREND OF INDUSTRIAL BUILDING CONSTRUCTION

The present trend of industrial building construction is indicated by a recent investigation made by W. P. Anderson, president of the Ferro Concrete Construction Co. of Cincinnati, Ohio, and presented in a paper before the recent annual meeting of the American Concrete Institute in Chicago. The results of Mr. Anderson's investigation were drawn from inquiries made of the leading industries, manufacturers of all classes of metal goods, manufacturers of textiles, paper, leather, boots and shoes. Of the representative manufacturers who were requested to furnish data, 370 concerns contributed information covering 1230 buildings erected during the period covered by the investigation. These varied greatly in size, use and construction but all were used for industrial purposes. The returns year by year are graphically represented in the

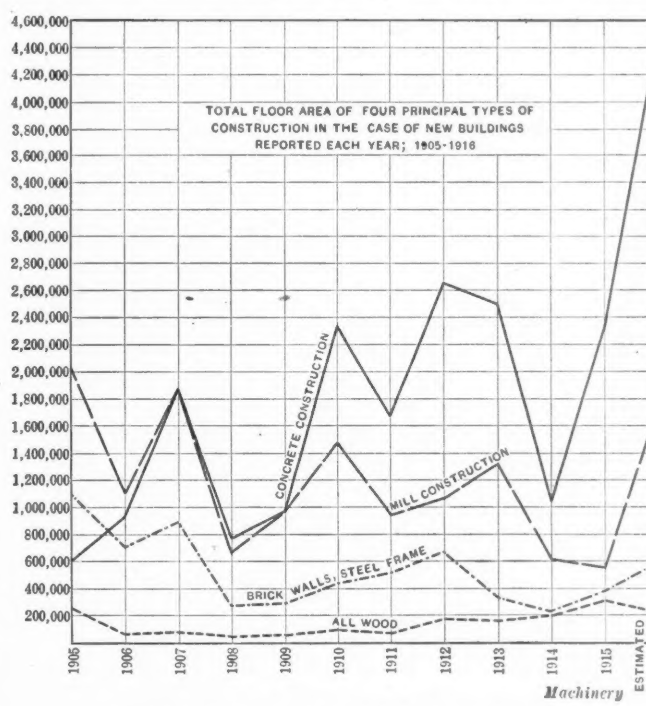


Chart showing Trend of Industrial Building Construction

accompanying chart for the four major classifications—all wood, brick walls (steel frame), mill construction, and concrete construction. Of course the abnormal disturbances during 1914-1916 account for the great fluctuations in that period. But even up to and including 1913, the advance of concrete construction and the relative decadence of other types are distinctly noticeable. The comparative growth of the various types of building construction is most strikingly shown by comparing the periods 1905-1910 and 1911-1916. In the former, the returns cover 7,014,218 square feet of mill construction and only 5,152,579 square feet of concrete construction, but in the latter period the area of concrete construction jumped 327 per cent, to 16,926,152 square feet, while the mill construction showed a bare increase of about 10 per cent or 7,709,469 square feet. The estimated area for 1916 was used in making up all of these comparisons.

## MECHANICAL DEFORMATIONS IN METALS

BY B. D. BALLANTINE[1]

It is interesting to know what changes take place in a metal when it is cold-worked, as, for example, when steel is cold-rolled or when brass is burnished. Sometimes it is exceedingly important for a machinist to know not only what effect a certain cold-working operation will have on the work he has in hand but also how this effect is brought about. In other words, he should understand something of the theory which governs these changes. By this knowledge he can oftentimes avoid annoyances that are likely to arise in regard to his work but that he cannot foresee if he goes at his work blindly. It is not the purpose, however, to give here a detailed outline of the theory, but simply to touch on its most salient features and to explain some of the everyday things that come up in connection with the cold-working of metals by the help of this theory.

When a metal has been strained beyond its elastic limit, allowed to rest for a short time, and then strained again, it is found to have a higher tensile strength than before and its elastic limit is also found to have been raised. This statement applies to metals in general, and especially to steel. The theory of this phenomenon is not simple and has not been absolutely established, but it has come to that stage where additional information strengthens rather than weakens it, so that it is now almost universally accepted.

When a cross-section of a piece of steel which has been subjected to strain beyond its elastic limit is examined under the microscope, there appears on each crystal a series of fine dark parallel lines that are more or less wavy. These are technically known as slip bands and are caused by a breakdown in the crystal, one part having slipped on another part and caused a slight displacement. In Fig. 1 are representations of two adjoining crystals, showing how they look before and after they have undergone strain. The steps *S* are where these bands occur. The average height of the steps is about 1/50,000 inch. The dark appearance of the slip bands is due to the reflected light in the microscope.

A number of elements exist in allotropic forms. For instance, pure carbon exists as diamond and as graphite, and sulphur exists as crystalline sulphur and as an amorphous sulphur similar in appearance to thick molasses. When brass or steel is burnished, the crystalline metal is converted into an amorphous form, which is pressed down into the tool marks. This amorphous metal flows into the minute cracks and crevices of the machined material practically as a molten metal flows and adjusts itself until it presents a smooth surface. The metal, when in this amorphous state, is harder,

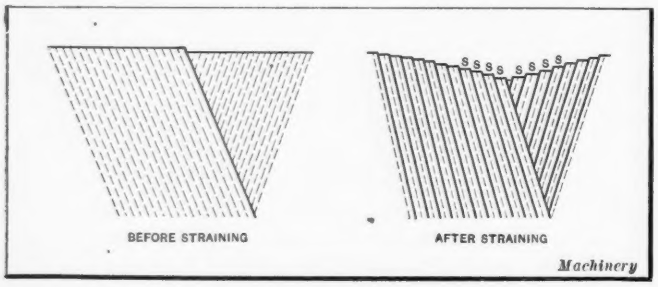


Fig. 1. Slip Bands of Adjoining Crystals

stronger and more brittle than when it is in the crystalline form, but it is more easily attacked by acids; in fact, so much more so that the original tooled surface can be restored by etching with nitric acid. The amorphous metal has a higher vapor tension also. When it is subjected to a high temperature in a vacuum it will sublimate off appreciably faster than in the crystalline form; it can be reconverted into the latter form, however, by being heated and then allowed to cool. This heat-treatment is known as one form of annealing and is the treatment used for softening brass.

When slip bands are created, a certain amount of crystalline metal is converted into the amorphous state, which flows around each slip band. Virtually all the metal at each slip band is changed in this manner into the amorphous condition. This acts as a cementing material, and, since it is harder and stronger than the original composition, the larger the number of slip bands created, the greater will be the amount of cementing material formed and consequently the harder and stronger the resulting material. Of course, if the thing is carried too far, ultimate fracture will result. The amorphous form is brittle, so when no available crystalline metal is left the metal loses its ductility, there is no more "give" to it, and it cracks. Everybody knows what the head of a well used cold chisel looks like, and so is familiar with the result of overstraining the metal. It must not be imagined, however, that all the crystalline metal is converted into the amorphous form. The process is carried on until a skeleton of the amorphous metal pervades the mass; a further carrying on of this straining operation will break down this skeleton.

The foregoing discussion leads to an interesting case. The fact is widely appreciated that a steel of fine grain is more

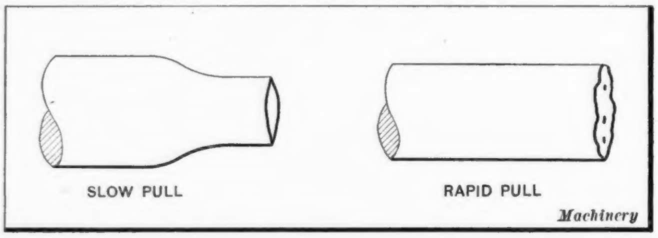


Fig. 2. Characteristic Appearance of Steel Bolt broken by a Slow and a Quick Pull

desirable than one of coarse grain because it is stronger. When molten steel cools and crystallization sets in, the nuclei of the crystals are first formed. As these crystals grow and as others form, they approach one another and a certain amount of molten steel is trapped, giving the crystals no more room to form. When this trapped material solidifies, it does so in the amorphous form. Consequently there is produced the condition existing in the preceding case, where the greater the amount of amorphous metal, the greater is the strength of the steel. As the amount of amorphous metal increases with the diminishing size of the crystals, a steel containing small crystals is stronger than one containing larger ones.

There is prevalent among machinists and metal workers a belief in the existence of the so-called "cold crystallization" of steel. The idea is that a steel originally of fine grain gradually assumes a coarse structure when it is subjected to continued alternate stresses and strains. No evidence to bear out this belief has been submitted to metalographists. A great many bolts and springs, broken after continued service, have exhibited what appears to be a coarse structure at fracture, but this does not warrant any such belief. The specimen will show its original grain if examined anywhere else than at the fractured surface. This coarse appearance at the break can be ascribed to other causes. Everybody has observed the behavior of a long piece of sealing-wax or of molasses candy. The stick can be bent almost double if a very slow and steady pressure is applied to it, whereas it will be broken off short if a sudden effort is made to bend it. Exactly the same thing is true of steel.

Fig. 2 shows the characteristic appearance of a steel bolt or bar when broken by a slow pull and when broken by a quick one. In the first instance, sufficient time has been given for slip bands to form, amorphous metal has had a chance to flow, and the result is a smooth break. In the second case, no such opportunity has been given for the amorphous metal to run and the fracture, which in any normal material always occurs through the crystals themselves, presents a ragged appearance in the absence of any filling-in material. But that is not all. When a bolt is subjected to alternate stresses and strains, slip bands will start to form. These will begin at a certain point and gradually spread from crystal to crystal. In the course of time the amorphous metal formed at these slip bands will be squeezed out by the intermittent pressure on the bolt and a minute crack will be formed. As the process

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is continued, the fracture will be extended until the unaffected portion of the bolt will be unable to bear the strain and breakage will occur. If these operations are carried on fairly rapidly, the steps caused by the slip bands, having had no chance to wear smooth by abrasion, will present a coarse crystalline appearance which has led to the mistaken notion that the metal has crystallized in coarse granules. If the process is carried out more slowly, the two surfaces, one on each side of the crack, will rub against each other, wearing each other down until they are smooth. Then when the bolt breaks, there will be a region on the fractured surface where this action has taken place that will appear rather smoother than the cross-section of that part of the bolt giving way last. This is only one instance of an illusion dispelled. There are many others connected with the science of metalography. As a rule, mankind does not go far out of its way to make discoveries unless compelled to. Urgent needs have fostered important discoveries and aided necessary developments. What the Civil War did for drop-forging in creating a demand for interchangeable gun parts in large numbers, what the present war is doing for the aeroplane, the automobile has done for the science of metalography; and the whole metal-workers' realm is affected.

* * *

## ORNAMENTAL MACHINE SCRAPING OR FROSTING

The slides and ways of machine tools are scraped for two purposes: first, for correcting faults of machining, and second, for ornamenting the working parts. When correcting faults the scraper is used with a surface-plate to bring the flat surfaces to true planes. The practice has the merit of hardening the surfaces, removing the cast-iron dust and putting them in first-class condition to resist wear. As planers were improved and planer practice was developed, it was found that surfaces could be planed so smooth and true that scraping as a corrective process was no longer necessary. Of course it would be far from the truth to say that scraping still is not largely employed as a corrective process, but this is chiefly the fault of the machine tool equipment and operation. There is no valid reason why a lathe or planer bed or table cannot be planed so true that it will require no corrective hand work. The true function of scraping these parts should be to clean

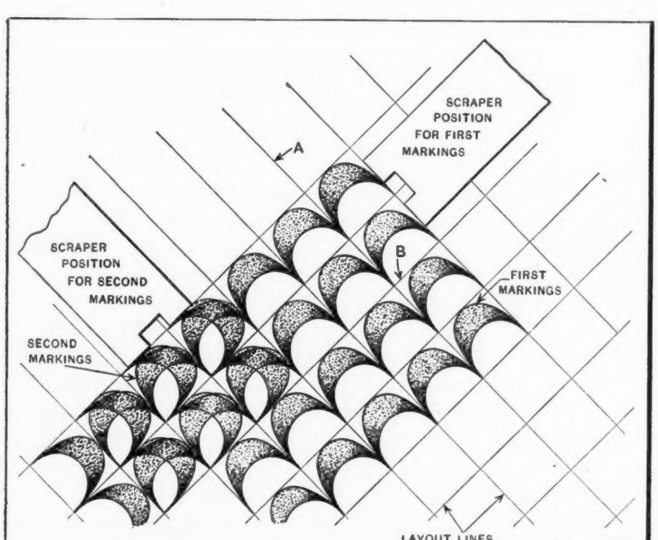


Fig. 1. Lund Method of frosting Machine Tool Slides

off the cast-iron dust, harden the surface so that it is in good condition to resist wear, and improve the appearance, if ornament is desired.

There are various methods followed in producing ornamental or frosted scraping; one that is simple, attractive and easy to produce is used by the Valley City Machine Works, Grand Rapids, Mich. The method was developed by Matthew Lund, vice-president and general manager, when he was employed as a mechanic in the plant of Bement & Miles, Philadelphia, Pa., years ago. The surface to be frosted by Mr. Lund's method is laid off as shown in Fig. 1, in squares measuring about ½ inch, and ¾ inch on the diagonal. The scraper used, shown in Fig. 2, has a notched edge; the width of the two points and the notch is ¼ inch each, the width over-all being ¾ inch. The lay-out lines are marked with a lead pencil, the lines showing black on the polished surface. The use of chalk on a finished surface is never advisable, as it is likely to remain in the pores of the metal and cause rusting years afterward. It is said to be practically impossible to get chalk out so that it will not plainly show effects long after the machine has been put in use.

Having laid out the surface to be scraped, the operator begins at a convenient spot, using the tool with a long pipe

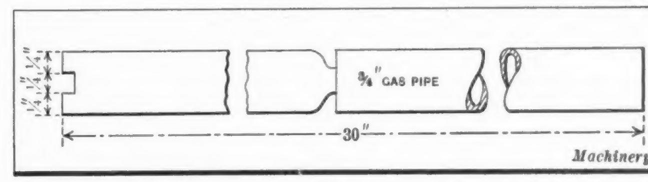


Fig. 2. Scraper used for producing the Lunar Markings

handle which rests on his shoulder. The tool is ground with a sharp chisel edge, and is not used as a scraper usually is, that is, to cut away the metal with a square corner. In fact, the function of the scraper is more of a marking tool than of a metal removing tool. The edges of the scraper are placed, say, on the line *A* with the left-hand side coinciding with line *B*. The tool is then given a sweep through a half circle ending with the left-hand side again next to line *B*. The results of the sweep are indicated by two lunar markings. This stroke is used progressively following the lay-out lines, and the markings are made rapidly. The second markings are produced in the same manner, but with the scraper held at right angles to the first position. The effect is pleasing, the work being regular and the light and shade effects all that could be desired for an ornamental frosted effect.

Of course it is understood that the surfaces scraped in this way have been proved beforehand with surface-plates and corrected when necessary by scraping in the ordinary manner. The marks of this scraping are eliminated by rubbing with emery cloth in a line parallel with the length of the ways. This leaves a surface in prime condition for the ornamental marking with the special tool.

Mr. Lund has instructed many mechanics in this method of ornamental scraping, and the practice has spread to other shops. It was instituted in order to secure uniform work from a number of operators, so that operator No. 23 working on the carriage of a machine, for instance, will finish his work in the same style as operator No. 50 who is working on the bed-plate. But it is also rapid; the time required to mark a surface a foot square in this manner is about one-half hour. Hence it is evident that the frosting work on a fair-sized machine tool need consume only a few hours. Of course we all concede that it is in a sense unnecessary, yet it adds greatly to the attractive appearance of a machine, and appearances count for a good deal in marketing high-class machinery in normal times. F. E. R.

* * *

Members of the Atkins Pioneers, men who have been associated with E. C. Atkins & Co., Inc., Indianapolis, Ind., for twenty years or more, celebrated the eleventh anniversary of their organization, with a banquet at the Spencer House in Indianapolis, Ind., Saturday evening, February 10, and a theater party at the Circle Theater. The Pioneers were organized in 1906, with sixty-two members, and the present membership is 121. John H. Wilde, the oldest member, who had a record of fifty-one years' continuous service, died last September. C. F. Aumann, the present treasurer of the association, is the oldest living member, having been in the Atkins service forty-seven years. Membership in the Atkins Pioneers is open to all employes. The object of the association is to promote sociability, loyalty and zeal for the business. The officers are W. O. Williams, president; C. S. Bronson, vice-president; C. A. Newport, secretary; and C. F. Aumann, treasurer.

# MACHINERY

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## MANUFACTURE OF STEEL BALLS

There is no other simple machine element that is regarded with more interest by those who know than a perfect steel ball; and it is with great satisfaction that we present in this number the first installment of a comprehensive article on ball manufacture. Steel balls suitable for high-grade bearings must be perfect spheres of hardened steel, highly polished; they must be without flaws or cracks, of uniform density and of high crushing strength. The hardness must be uniform and extend to the center. While the requirements are severe, they have been met in such measure as to make the highest grade balls an ideal product.

The machinery and processes employed in the manufacture of balls are unique, being peculiar to that industry alone. The ordinary turning and finishing processes of the machine shop cannot be employed for making balls, as they are too slow and costly and too inaccurate. Machining methods quite different must be used for manufacturing balls for bearings. Machines and methods have been developed which have put the making of balls on a tonnage basis, but, paradoxically, these machines are not in themselves of such exquisite refinement as to warrant the conclusion that the product will meet the most exacting requirements. As a matter of fact, ball making machines are crude, but they subject the rough forgings to peculiar abrasive and rolling actions, which tend to produce a truly spherical form. Not all balls produced are perfect—far from it; but by ingenious sorting and grading machines and sensitive gages the inferior grades are eliminated.

The importance of the ball making industry can hardly be over-estimated. Ball bearings are an essential feature of many modern machines, and the number using anti-friction bearings is growing. There is, perhaps, no feature of machine design that requires more study than the proportioning of bearings so as to give the longest life consistent with a minimum of frictional resistance. But, at best, the design of plain bearings is a compromise. Ball and roller bearings are steadily displacing them, as is shown by the millions annually produced. The factory whose practice will be described in these articles is now producing the equivalent of 25,000,000 one-fourth-inch balls daily, and will soon be able to increase its product over 60 per cent.

## IMPORTANCE OF STANDARDIZATION

Perhaps the most valuable and enduring work of the American Society of Mechanical Engineers is the recommendation of standards of practice for engineers, such as the screw threads and boiler design standards. Standardization of practice means increased efficiency of production, less waste of material, and greater security. Howard E. Coffin, in an address delivered before a body of engineers recently, dwelt strongly on the need of standardization of aeroplane parts. He cited the case of one concern making screw machine parts for nearly all the aircraft built in the United States and Canada. One form of bolt is common in all the designs; but this bolt is requisitioned in eight different materials, several diameters, six styles of heads and fifty different lengths. This means that the one concern may be called on to produce several thousand different styles and sizes of one bolt, which might be used with equal satisfaction if standardized in one size and style.

The folly and waste of such practice is appalling. It is due largely to the reluctance of one designer to accept the figures and forms laid down by another, and to lack of appreciation of the savings effected by standardized practice. The intelligent, progressive and efficient engineer should be willing to accept the designs of others when reliable; acceptance is a step toward standardization.

We have had occasion several times to refer to the extraordinarily valuable standardization work accomplished by the Society of Automobile Engineers. This being a young society, unhampered by precedent and devoted to the interests of a comparatively new industry, has had a great advantage over the older societies. Its committees have risen to the occasion and by standardizing motor car details have saved the industry millions of dollars and set an example for other engineering societies to follow.

* * *

## DELIVERIES OF MACHINE TOOLS

Price and delivery are very important items in any contract or order for machine tools. During the past two years, delivery has usually been a greater consideration than price. Some manufacturers who would not think of quoting a machine at $3000 with the intention of accepting the order and invoicing it at $4000 will deliberately name a delivery of three months and take the business with the full knowledge that they cannot hope to make shipment in less than four months. The latter practice is not so reprehensible as the former would be, but to deliberately name an earlier delivery date than can be met is morally wrong and financially short-sighted; it is harmful to the company indulging in such practice, and it gives the machine tool industry a bad reputation.

Some companies which consistently fail to maintain promised delivery dates do not do it with intent to deceive, but they do base their promises upon the best attainable deliveries if there should be no hitch at any point in the entire manufacturing schedule. Invariably something goes wrong, thus introducing more or less delay. With a proper production schedule, the machine tool builder should be able to predict very closely the date at which any given order can be filled—barring strikes, fires and accidents. One of the leading machine tool manufacturers has for some months been deliberately adding about 20 per cent to its shop production schedule when making promises of deliveries, knowing that the dates thus calculated can be easily anticipated. The result is that shipments, instead of being late, are made ahead of the promised dates. This has brought a number of unsolicited commendatory letters from customers who have received their machines earlier than promised, and much earlier than expected. It is building up good will for that company in the way of reputation for more than fulfilling obligations in the way of delivery promises.

If this practice should come into general use, no manufacturer would feel that he was losing business on this account, because all would be on the same basis. It would give the American machine tool industry, in general, a much more favorable reputation abroad; and those firms which first gain the reputation for meeting delivery promises will derive the most benefit.

## THE ASSUMPTION OF RISK

BY CHESLA C. SHERLOCK [1]

The doctrine of law that a servant or employe upon entering certain classes of employment, assumes the ordinary risks and dangers of the employment is an important branch of the law of master and servant. Reaching into almost every branch of our industrial life, its importance can be comprehended only when one has realized how far-reaching our commercial and industrial world is.

It is a fundamental proposition that a servant assumes the ordinary risks and dangers of the employment in which he is engaged. The courts have even gone further and said that he also assumes the extraordinary risks and dangers that he knows and appreciates. And here is one of the most fertile fields for disagreement among the authorities. Just how far an employe assumes apparent risks, what risks are apparent and what are not, and the like, are questions that not only puzzle the most capable lawyers but the text writers and the courts as well.

Speaking in specific cases where the risk of employment was obvious, the courts have handed down a long list of conflicting and varying decisions. One court has held that an employe assumes all risks connected with the business with which he is employed, even though produced by the master's negligence, if he continues in the employment. A railway company is not liable for the killing of a conductor struck by a trolley pole while he is leaning out of a car running at high speed on a straight track at broad daylight at a place with which he is familiar, in order to ascertain a fact that he can learn by looking out from the rear of the car, since the conductor voluntarily chooses the negligent rather than the safe way.

As to employment that is obviously hazardous, the courts held, in a case where a salvage company was called upon to clear away the debris from a burning building, that one who engages in such work assumes the risk of injury from falling walls. It was also held in this case that "an employe of one engaged in salving property from the debris of a fire cannot hold his employer liable for injuries caused by falling walls; since, if the danger was obvious he assumed the risk of injury, and if it was not obvious the master did not violate his duty to use ordinary care to provide a reasonably safe working place." An employe sent to remove a pile of lumber assumes the risk of injury from its fall, because the lumber is covered with ice and defectively piled, where the defects are plainly obvious to him, notwithstanding they are due to the master's negligence.

These cases illustrate the tendency of the courts in instances where the facts show that the defect causing the injury was obvious, or must have been obvious, to the employe. In the case of defective machinery, appliances, or methods of work, a little different construction obtains. In a case where a nail projected above the floor in the immediate vicinity of a dangerous machine and a workman tripped on the nail and was thrown into the machine, it was held that there was no assumption of risk. This decision was based on a showing that the nail was habitually covered with litter, so that, as a defect, it was not obvious. However, when a servant remains, without necessity, under a heavy steel plate that is being hoisted in the air by means of a tackle, he assumes the risk and, if injured, cannot recover. One operating a lath machine has been held to assume the risk of injury from being thrown against the saws by the breaking of a stick or strip of lumber with which he undertakes to clear the chute carrying the sawdust from the machine.

An employe does not assume the risk of a device, installed by his master to lessen the risk of injury from the machinery at which he is required to work, being permitted by the employer to get out of order, unless he himself has notice of the fact that it is out of order. A servant who assumes the risk of getting his hand caught in a machine at which he is required to work may hold his master liable for aggravation of his injury by failure of a device installed to stop the machine in case of such accident to work, should his arm be drawn into the machine and crushed. A servant does not, by continuing to operate a machine that has not been protected by guards as required by statute, assume the risk of injury from violation of the statute. A servant does not assume the risk of injury from the master's violation of a statutory duty to guard set-screws. An inexperienced employe injured four days after his employment by an unguarded set-screw was found not to have assumed the risk of injury therefrom, although he knew of its existence, as the injury was due to the yielding of sawdust under his feet throwing him against the screw, the probability of which he might not have anticipated.

The defense of assumption of risk in its true sense in an action by the servant for injuries caused by the master's negligence has reference to those risks arising out of the negligence of the master that are known to, and the danger from which is appreciated by, the servant. A servant does not assume the risk of injury from the negligence of his master merely because he could have discovered and avoided it by the exercise of ordinary care; his assumption of such risk depends upon his actually being aware of and appreciating the danger. The test of "knowledge of danger" in determining whether an injured employe had assumed the risk is not the exercise of ordinary care to discover danger, but whether the danger was known to or plainly observable by the employe. A servant who knowingly engages to do what no prudent man ought to risk his life in endeavoring to accomplish cannot, if injury ensues, rely upon the law to throw around him the protection of a fiction that his employer impliedly undertook to take steps to minimize the hazard assumed, at least to the extent of making performance possible.

Where a servant discovers a defect in his tools or place of work that greatly increases his danger of injury and reports it to his master, he has not, by merely doing this, removed himself from behind the defense of assumption of risk. If the master promises to remedy the defect and on the strength of the promises the servant goes back to work, the doctrine of assumption of risk is still in force and, in case of injury, the servant cannot recover from the master for his negligence. Some of the courts, however, hold that where the master promises to remedy the defect before a certain time, as an inducement for the servant to return to work, he is liable up to the specified time; but that if the servant continues to work after that time the liability of the master ceases. If a master's promise to repair a defective machine is general or inferential as to the time of its performance, it runs for a reasonable time, and if not performed within such period, the servant assumes the risk of injury if he continues to operate the machine. To entitle a servant to take advantage of a promise by the master to repair the machine upon which he is required to work, the promise must have been the inducing motive which kept him at work and without which he would have quit.

The doctrine of assumption of risk by the servant not only applies to the master's negligence in the cases mentioned, but it applies to the negligence of fellow servants. It is a fundamental principle that fellow servants assume the risk of injury from one another in their common conduct of the master's work. Practically the same principles of law that govern in cases between master and servant hold in cases between a servant and a fellow servant. At least, it is safe to say they do in general principles, although there are distinctions in almost any phase of law that negative any attempt to state a broad general principle that will apply in all cases.

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Preliminary estimates by John D. Northrup, of the United States Geological Survey, Department of the Interior, indicate that the quantity of crude petroleum produced and marketed in the United States oil fields in 1916 was 292,300,000 barrels. This quantity is greater by 4 per cent than the corresponding output in 1915, which reached the record-breaking total of 281,104,104 barrels. Mr. Northrup estimates that 38 per cent of the 1916 total came from the Oklahoma-Kansas field, 30 per cent from California, and the remaining 32 per cent from the Appalachian, Lima-Indiana, Illinois, North Texas, North Louisiana, Gulf coast, and Rocky Mountain fields.

# SHOP TRAINING FOR MACHINE TOOL SALESMEN

BY ALFRED A. BERKWITZ [1]

In recent years there has been a great deal written on salesmanship, and the subject has been considered from every angle. But one point is accepted by all writers; namely, that the salesman should have a thorough knowledge of his product. For this reason, most concerns send their technically trained young men to the factories for a varying period of time as a preparation for the sales department. There is no standard method of training in use among the different concerns. Some require the shop training before the men enter the sales offices; others prescribe a short term of office work before the men go into the shops. The writer is in favor of the latter method, because the salesman learns the methods of doing business, and, furthermore, at the end of this period knows just what he needs to learn while in the shops.

It is highly advisable that this shop training should be concentrated, and not too long. The average technically trained man does not take long to master as much of the shop practice and machine construction as he will need. Furthermore, since a salesman must know men as well as methods, he should be allowed considerable freedom while at the plant. The man who spends several weeks over a drawing-board detailing some gear or lever learns a certain amount, perhaps; it is certain, however, that he does not learn nearly as much as if he had spent the same length of time as recommended in the following. From the writer's experience as an instructor (secondary school and university), the method here outlined presents a logical means of obtaining the necessary shop training, in a concentrated manner.

After the salesman arrives at the plant, the first few days are spent in becoming acquainted with the various officials and inspecting the whole plant, in a general manner. Much depends on "getting in right" at the start. The serious part of the work then commences, and the first machine is taken up. Let us suppose that it is a boring mill. The writer frankly confesses that beyond the fact that a boring mill consisted of a revolving horizontal table and a stationary tool, to him the rest of the machine was simply a series of levers and covered boxes containing numerous gears, clutches, etc. A nearly completed mill in the shop should be chosen for the first inspection. At the outset, one fundamental principle common to almost every machine tool should be understood: the power applied to the machine is divided into two main branches, the driving of the tool or table, as the case may be, and the feeds. In the case of the boring mill, the power is traced from the belt or motor through the various speed gears and back-gears to the pinion which drives the table. The writer strongly recommends sketching these gear trains on a pad; the very act of putting a construction on paper helps to fix it in one's mind. In the same manner, the feed gearing is traced through from where it leaves the drive gearing to the final tool movement. If any part of the machine is inaccessible, the assembling benches should be visited and the desired part inspected in detail. In this way, a fairly good understanding of the function of each lever and clutch is obtained.

The next step is to hold an informal consultation with the designer of the tool. With his assistance, a number of assembly drawings of the machine in question should be selected from the files; ordinarily about four or five will be sufficient to show the general construction. It is advisable to choose only such drawings as will show the various parts of the machine assembled; too many detailed drawings are likely to cause confusion. These drawings should be gone over carefully with the designer and anything not thoroughly understood should be discussed. Blueprints should then be made and kept in the salesman's files for reference.

The question may arise as to the advisability of looking over these drawings before making the preliminary inspection of the machine instead of afterward. The writer believes that the latter method possesses several advantages over the former. In the first place, it is much easier to see a thing in reality than on paper. Then, in going over the drawings, the designer will usually refer to various parts of the machine, presupposing a slight knowledge of its construction on the part of the salesman. If he has not this knowledge, constant explanations are required which may be very annoying to the designer. On the other hand, if the main features are understood, it is much easier to grasp the inter-relation of the various mechanisms, especially if the tool is complicated. In addition, many good talking points on the various constructions can be obtained, since the salesman's attention is not absorbed by the mastering of details, and more time is had for generalization and for comparison with other makes of machines.

After the drawings have been studied, it is a good plan for the salesman to make a brief tour through the shop with the designer. By this means, every point discussed in the conference is brought home by actual inspection and the design of the whole machine is firmly fixed in mind. The concentrated study of that machine may now be considered as ended, though, from time to time, inspections will be made of various types in different stages of erection. Furthermore, it is an excellent plan for the salesman to have frequent chats with the men who operate these machines in different parts of the plant. Much valuable information regarding the output, mode of operation and special advantages may be obtained from them. This is of service if the salesman's prospect is a "mechanical" man—one who is appealed to from the operator's viewpoint.

As the salesman, both in his training and afterward, is brought in contact with numerous workmen, foremen, and designers, as well as other officials, the smoother and the more cheerful he makes his path, the better and more successful will be his results. Due either to experience or to prejudice, many foremen and designers who have worked up from the ranks have no use for a college-trained man. Although the greater part of this prejudice is unfounded, there are occasionally good causes for it. Most technically trained young men emerge from college with a large quantity of self-confidence, a good thing in itself. However, some are inclined to assume a condescending manner toward a man whose education has been obtained in the school of hard knocks. The latter are rather sensitive on this point and readily detect and resent any attempt to display superior knowledge. It is always well to listen to their side of the story, remembering that everything they state is from experience; if they are wrong, it is usually possible, by using a bit of tact, to show them the correct solution or method. If they are correct, their methods should be warmly commended; a word of praise here and there is a great lubricating agent. The average modern workman has a profound respect for education. Anyone who is interested in his welfare is his friend.

After a machine has been studied in the foregoing manner, it is a good plan for the salesman to accompany the inspector on his final tests. Much can be learned from him. He usually has had extensive experience and possesses a veritable storehouse of anecdote and history concerning various machines and their development.

Much the same procedure is followed with each machine, although, after becoming more experienced, the salesman can carry on the study of two or even three machines simultaneously. However, it is better to concentrate on one machine at a time, if the available time will permit. Along with his practical training, the salesman should keep up an extensive technical reading in all lines. A knowledge of present conditions and of the trend of improvement and development in his field is of great importance. A further aid is the inspection of any outside plants within convenient distance. On these visits the salesman becomes acquainted with the conditions which his machines have to meet, the methods of manufacture, and the requirements upon the machine-tool builder. He also learns the demands of the users of machine tools. He should transmit this information to his shops, and if he suggests any improvement of value, it should be carried out. Frequently, though, a salesman will offer a machine with certain attachments which are of little service to the user but are a source of trouble to build. If the salesman knows his machines thoroughly and also his own factory conditions, he can often guide the purchaser in his demands.

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# GAGING AND INSPECTING THREADS—2

### DEVICES FOR TESTING LEAD OF TAPS AND SCREWS

BY DOUGLAS T. HAMILTON [1]

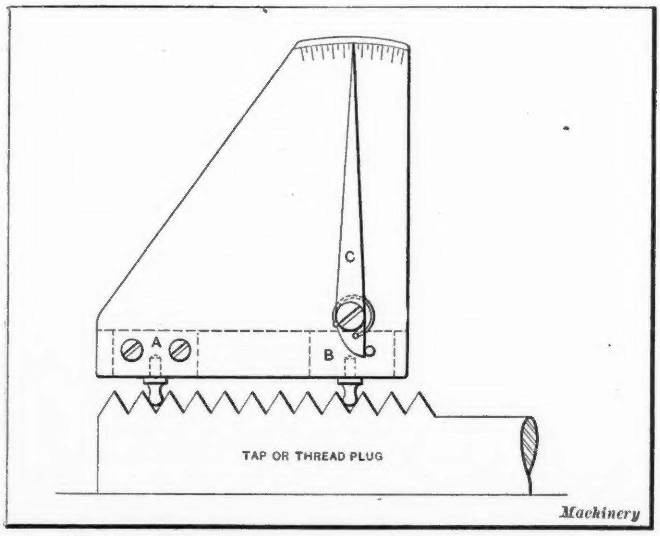


Fig. 16. Simple Device for testing Lead of Taps and Screws

WHILE the pitch of a screw or gage bears a definite relation to the pitch diameter, these two elements are generally tested separately, although, as will be subsequently described, devices are made for testing both at the same time. This is only done, however, when it is desired to make parts, such as screws, etc., interchangeable, and not when producing gages.

#### Simple Device for Testing Lead of Screw Threads

Fig. 16 shows a simple device which is used as a comparator for testing the lead of taps and screws. It consists of a fixed block *A* and a sliding block *B* held in a frame as illustrated. The blocks are provided with pointers having ball points. The sliding block operates an indicating needle *C* which, on a magnified scale, indicates the error in lead. The manner in which this instrument is used is as follows: The position of the pointer on the scale is noted when the instrument is brought in contact with a standard plug that engages the ball point; the free block *B* adjusts itself to the thread into which its point enters and carries with it the needle *C*. Next the tap or screw to be tested is placed in position against the device. If the lead of the screw or tap is correct, that is, if it is the same as the standard, the pointer will occupy the same position on the scale as it did when brought in contact with the plug. If the tap or screw is long or short in lead, the pointer will show the amount by its movement either to the right or to the left. The circular arc of the scale is generally graduated to read to 0.001 inch.

#### Indicating Comparator for Testing Lead of Taps and Screws

A somewhat more elaborate device for testing the error in lead of taps and screws is shown in Fig. 17. In this, one ball point *A* is fixed and is mounted in slide *B*, which is operated by a knurled-head screw *C*. This ball point *A* may be screwed into any of the holes *D* which may be ½ inch apart. The other ball point *E* is inserted in a movable block *F* mounted on ball bearings. This block is connected, through lever *G*, with the indicator or sensitive gage *H*, which is so arranged and graduated that each thousandth inch can be easily read. When the standard plug is placed against the device, the ball points enter between threads the same as in the device previously described, and slide *B* is adjusted by the knurled-head screw *C* so that the indicator points to zero. When the screw or tap to be tested is placed against the ball points, any error will then be apparent by the motion of the needle.

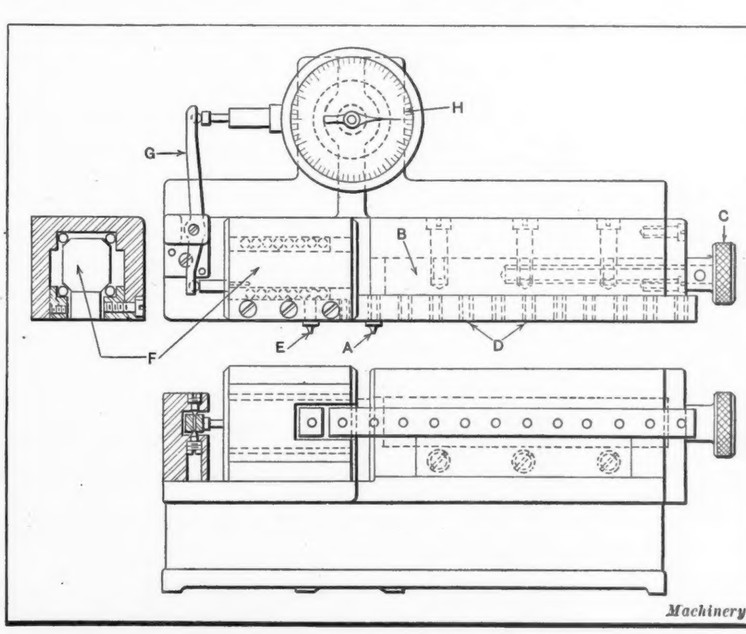


Fig. 17. Indicating Comparator for testing Lead of Taps and Screws

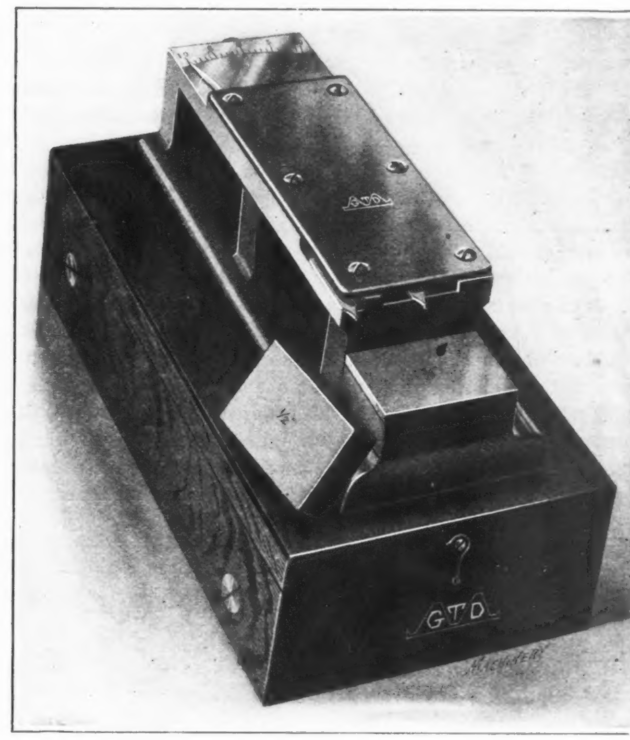


Fig. 18. Wells Bros. Rapid Screw and Tap Lead Tester

#### Wells Indicator for Testing Lead of Screws and Taps

A simple but effective device for testing the lead of screws and taps is shown in Figs. 18 and 19. This device is made by the Greenfield Tap & Die Corporation, Greenfield, Mass., and as shown in Fig. 18, comprises a base carrying one fixed and one movable pointer. These pointers are made to enter the threads of the screw, as shown in Fig. 19, the indicator previously having been set to zero by means of a reference plug. In using this device, the screw is simply pressed against the points and any deviation from the correct lead is shown by the indicator in thousandths inch. A set of steel blocks furnished with this device permits of the rapid testing of any size screw. The blocks vary in thickness, thus en-

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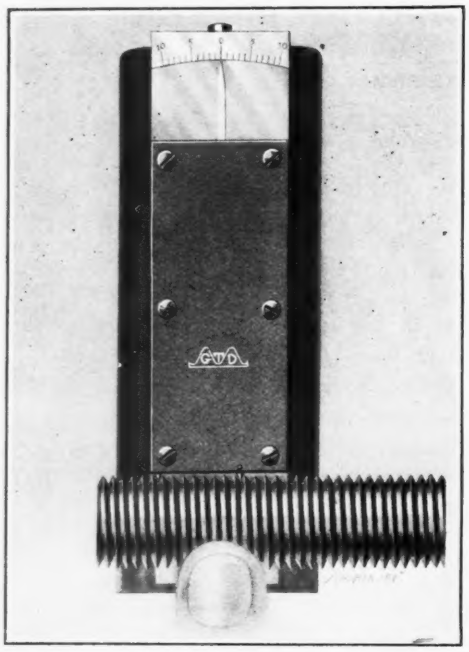

Fig. 19. Indicator shown in Fig. 18 in Use testing Lead of Screw

abling the screw to be placed at the proper height so that the points will come in the center or on the axis of the screw. The points are removable so that they can be replaced when they are worn.

### Wolfe Dial Indicator for Testing Lead of Taps

A dial indicator known as the Wolfe indicator, which is particularly adapted for testing the lead of taps, is shown in Fig. 20. It can be used for testing any screw or tap having a length of one inch or more, and an accuracy of 0.0002 inch is said to be easily obtained. The dial of the indicator is graduated to read to thousandths inch and has a range of 0.024 inch on each side of the zero mark. This instrument has two ball points *A* and *B*, which are brought into contact with the thread to be tested; point *A* is movable and point *B* stationary. Point *B* can be unscrewed from its socket and screwed

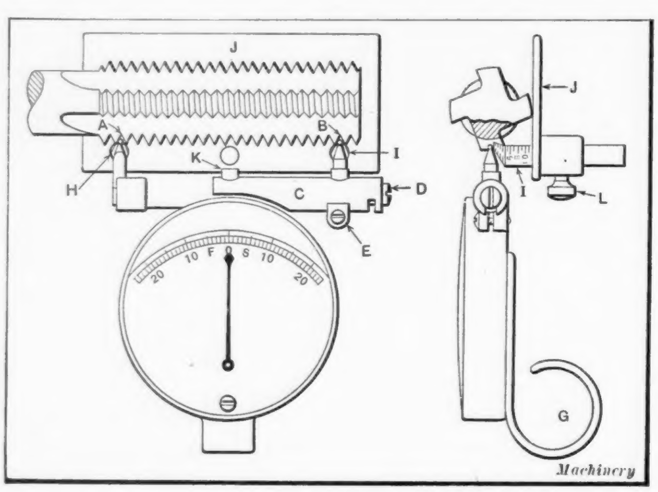


Fig. 20. Wolfe Indicator particularly adapted for testing Lead of Taps

into the socket *K* when a testing range of one inch is desired. Point *B* is held in a sleeve *C* that can be adjusted by screw *D*, the sleeve being held in position by clamping screw *E*. The loop or handle *G* is used for holding the indicator.

In addition to the indicator proper, a centering gage provides a means for enabling taps, screws, etc. to be tested on the center line, thereby insuring the required accuracy. This centering gage can be used on taper as well as straight taps and has a capacity for diameters ranging from 1/4 to 1 1/2 inch. The adjustable points on the centering gage are graduated in thirty-seconds of an inch and they may be held in position by thumb-screws *L*.

As the illustration shows, this centering gage also has a main plate *J* against which the piece being tested is held. When using the centering gage the graduated points are set out from the plate *J* at a distance equal to the radius of the tap or screw to be tested. Thumb-screws *L* are then tightened, thus holding the points in the adjusted position. The tap or screw is next placed in the centering gage and is held down on plate *J* and against the points. The indicator, of course, is held in the hand with the second finger through the loop *G*. The gage is brought so that the stationary ball point *B* enters the thread and rests on the flat end of point *I*. The movable point *A* enters the thread and rests on the flat part of the point *H*. The indicator will then show whether the thread is "fast" or "slow" in thousandths inch. If the thread is accurate, the needle will remain at zero. If it is "fast," the pointer will move in the direction of *F*; and if "slow," it will move in the opposite direction.

### Lead Test Indicator

Figs. 21 and 22 show a thread test indicator used in the Pennsylvania Railroad shops for testing staybolts, taps, and lead-screws. This instrument comprises a standard on which is pivoted a sensitive spring pointer *H* and a stationary pointer *J*. The latter is mounted on a bar *K* which may be adjusted minutely lengthwise by screw *L*. The indications of pointer *H* are read on segment *M*, the support of which may be adjusted, through the circular dovetail slot, about the center of the pivot of *H* to bring the reading to zero. This adjustment is effected by screw *N* and clamped by screw *O*. Spring stop-screws *P* limit the extreme movement of the needle.

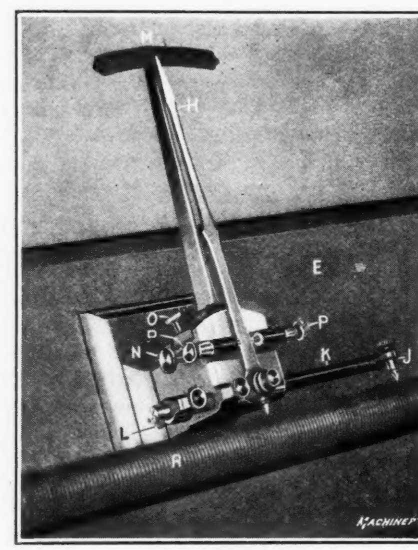


Fig. 21. Lead Test Indicator having Wide Application

In use, the points are adjusted to span a certain number of threads and the instrument is pushed up against the screw to be measured until the measuring points are firmly pressed into the thread. Scale *M* is then adjusted until the indicator points to zero. The instrument is then moved from one place to another along the thread and if the needle points to zero in all positions the thread is uniform.

Another use of this tool is in finding the amount by which the threads are longer or shorter than the true pitch. By this test, the indicator is first set to zero on a reference screw of known accuracy; the screw to be tested is then put in place and measurements are taken at various points along its length. The readings on the dial show whether the pitch is long, short, or regular and by how much. The indicator can also be used for measuring the size of thread at or near the pitch line. The indicating points are balls and various sizes are provided to suit the different pitches and shapes of threads. An

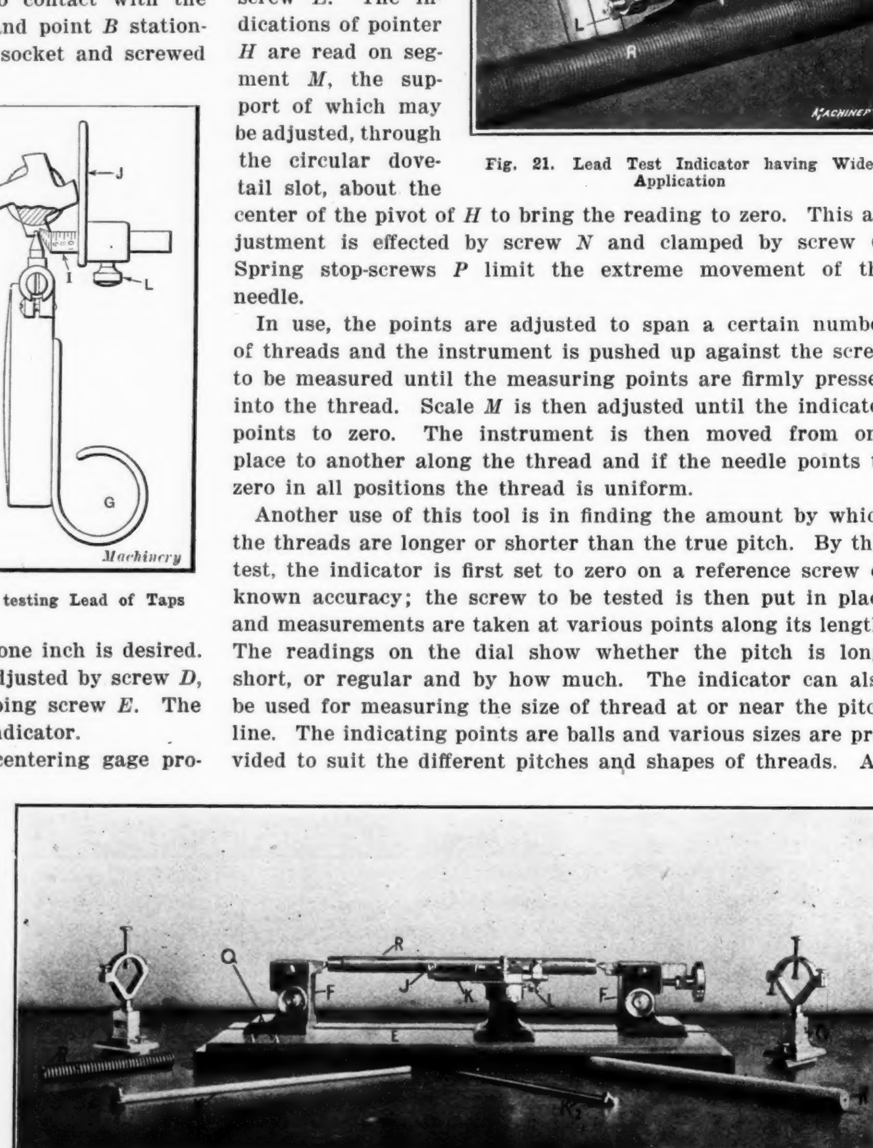


Fig. 22. Indicator shown in Fig. 21 in Use testing Lead of Long Screw

extra set is shown at $Q$ in Fig. 22. Various model screws for comparative measurements are also shown at $R$, and bars of various lengths for carrying the fixed indicating points are shown at $K_1$ and $K_2$. The whole arrangement makes the instrument practically universal in application, since base-plates of any length may be used and the centers or yokes fastened to them at the points required.

### Testing Included Angle of Thread

Fig. 23 shows a simple device for testing the included angle of a thread. This consists of a special base carrying two center supports, and a rear support or slide for holding cone-pointed inspection rods.

The procedure followed in using this device is to place the plug to be inspected on the centers, and then locate one of

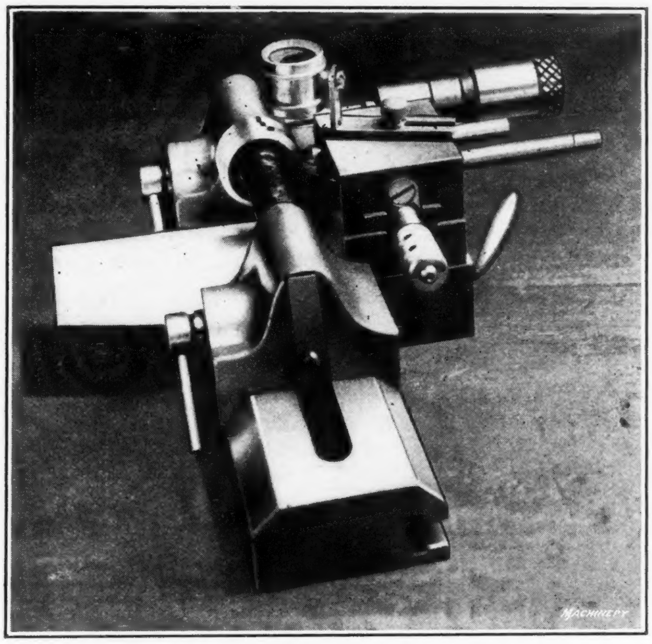

Fig. 23. Device for inspecting Included Angle of Thread

the cone-pointed rods with the carefully ground and lapped point in the space between the threads. A sheet of white paper, for illuminating purposes, is then placed on the base, as shown, and the thread viewed through the magnifying glass. If it is desired to determine just how much the angle is off, rods having points ground to included angles of 60½ or 59½ degrees are used, the angle depending on the pitch of the thread and the tolerances permitted. Usually, however, the thread is tested for "light", and if the cone point does not bear evenly on the angular sides for the depth of the thread it is not passed. By using the two points, which are spaced exactly one inch apart, it is also possible to test the lead with this device.

### Limit Working and Inspection Thread Gages

Most of the devices described in the foregoing are somewhat limited in their application and will not be found suitable

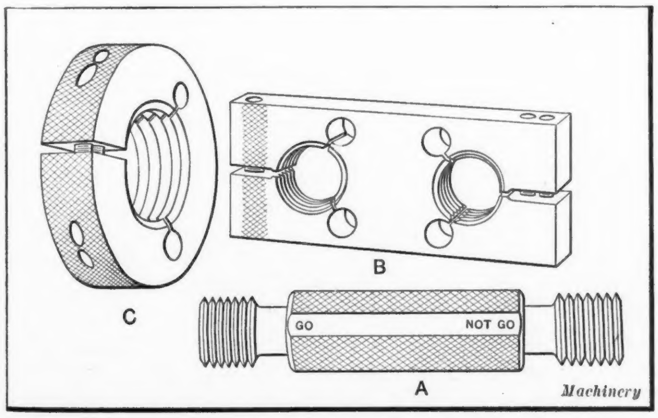


Fig. 24. Limit Working and Inspection Plug and Templet Screw Gages

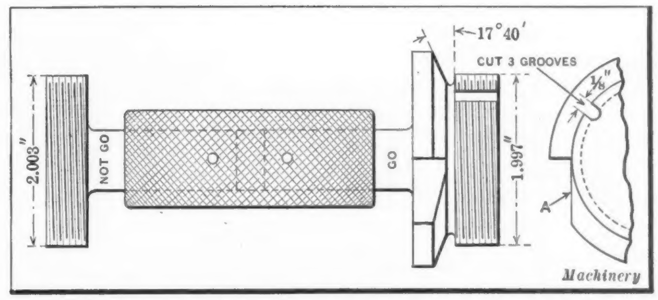


Fig. 25. Double-end Limit Plug Gage having Beveled Shoulder for inspecting Chamfered Thread Hole

when a large number of threaded parts are to be produced within certain limits of tolerances. As a general rule, gages are designed to handle one diameter and pitch of thread. The most common form of limit thread gage is shown in Fig. 24. For threaded holes, a limit plug gage $A$ having two threaded ends, one of which is made to enter the hole and the other not to enter (when the work is satisfactory) is used. For external threads, such as screws, etc., a templet, as shown at $B$, having "Go" and "Not Go" holes, is used; or for the larger sizes two rings, as shown at $C$ can be employed. The chief objection to these gages is that they do not indicate what element of the thread is in error. For many classes of work, however, they fill all requirements; especially when the necessary care is exercised in producing the tools used in cutting the threads.

The general practice is to use the double-end templet $B$ for sizes up to one inch in diameter; the "Go" end is knurled. For sizes over one inch, two rings, as shown at $C$, are used. These gages are adjusted to the plug $A$ and are set by means of interlocking screws, which cause the three lands to converge to a common center. For inspecting the U. S. standard

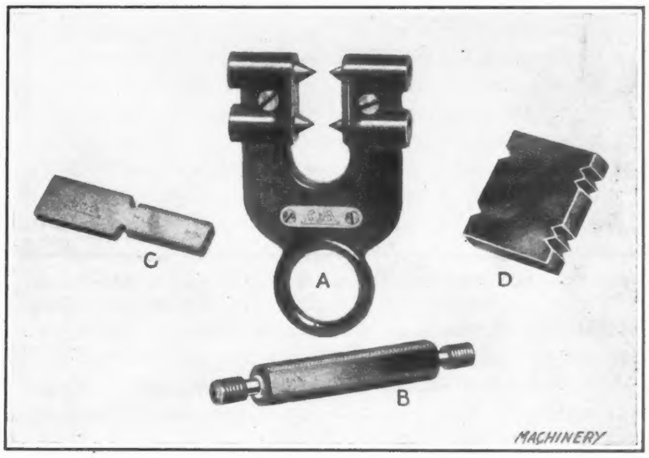


Fig. 26. Limit Snap Gage and Setting Plugs

thread, the threads in the ring and plug have flat tops—one-eighth the pitch—and sharp V-bottoms to clear fine chips, dust, and dirt, and also to insure a bearing upon the angular sides of the thread.

In cases where the threaded bushings, sockets, etc. are made with a chamfered mouth, the "Go" end of the plug gage, as shown in Fig. 25, is made with an enlarged shoulder, the front face of which is beveled to the angle required. This shoulder is then cut away, as shown at $A$, to provide a means for inspecting the accuracy of the angle. The threaded part has three grooves to collect fine chips and dirt.

### Limit Snap and Plug Gages for Threaded Work

A limit snap gage for threaded work, which is manufactured by the Greenfield Tap & Die Corporation, is shown at $A$ in Fig. 26. This gage is used for testing the pitch diameter of screw threads, and is provided with hardened cone points, carefully ground to the angle of the thread wall. The points are not placed directly opposite each other, but are offset an amount equal to one-half the pitch. The cone points are adjustable and are set by locking screws, which are sealed by the inspector after he has checked the gage. $B$ shows a setting

plug that is similar to the plug shown at *A* in Fig. 24 and is used for sizes up to ¼ inch. *C* is used as a setting plug for sizes from ¼ up to 3 inches; and *D* for sizes from 3 inches up.

Fig. 27 shows the snap gage illustrated at *A* in Fig. 26, held in a stand and used for the rapid inspection of screw threads. This illustration shows clearly the advantages of this gage. At *A*, the screw being tested is too small and has passed both sets of points; at *B*, the screw is too large and will not pass the upper or "Go" points; while at *C*, the screw is just right, as it has passed the upper points and is hanging on the lower ones.

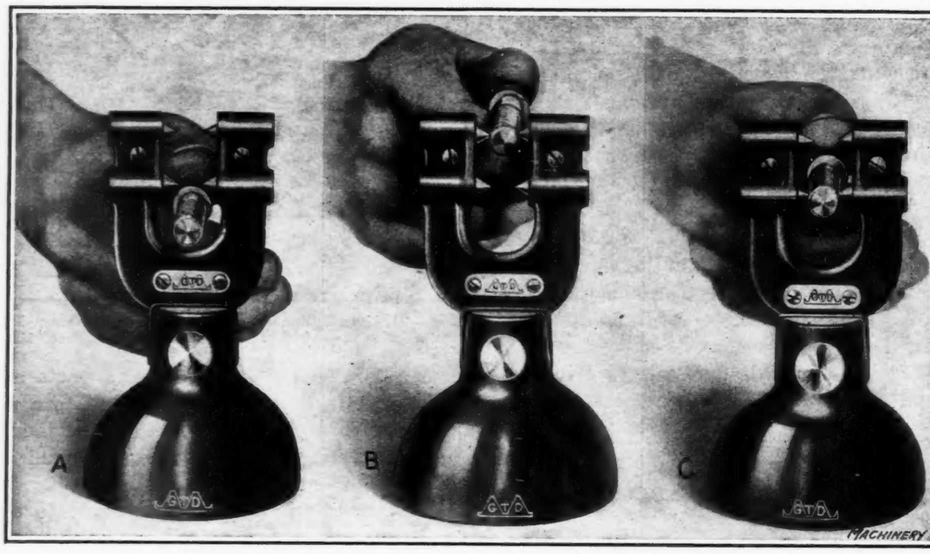

Fig. 27. Applications of Limit Snap Gage shown in Fig. 26

### Limit Snap Gages for Testing Lead and Pitch Diameter

While the cone points in the gage shown at *A* in Fig. 26 are set off an amount equal to one-half the pitch, they do not cover a sufficient number of threads to detect errors in lead.

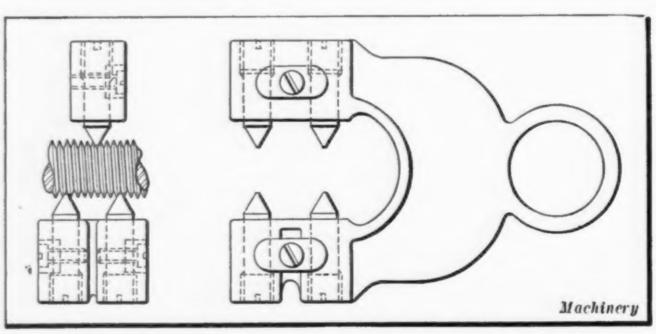

Fig. 28. Limit Snap Gage for testing Lead and Pitch Diameter

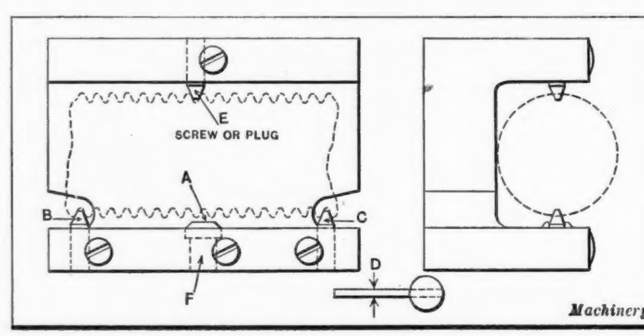

Fig. 29. Another Limit Snap Gage for testing Lead and Pitch Diameter

A modification of this gage is shown in Fig. 28. This is provided with two sets of three points, making six cone points in all. The points held in the lower jaw of the gage are spaced approximately ½ inch apart, depending on the pitch of the thread, and the upper points are offset from a line located equidistantly between the two lower points an amount equal to one-half the pitch. By the use of this gage it is possible to detect errors in lead which would prevent the screw and nut from going together as they should.

Another gage of the snap type, which inspects both the lead and the pitch diameter of a screw thread is shown in Fig. 29. This gage comprises a frame carrying three conical points *B*, *C* and *E*, which are accurately ground to the required angle; the extreme ends of the points are removed so that the points will contact with the sides of the thread. Points *B* and *C* are fixed in the lower jaw of the gage, so that their center distance is equal to an exact number of threads representing twice the length of a nut of corresponding diameter. The third point *E* is held in the upper jaw and is midway between the lower points. All three are set to a known standard. Located opposite the point *E* is a point *F* having a flat face *A*, which is adjusted so that the small cylinder *D* (which is of such diameter that it will touch the sides of the thread half way down its depth) will just enter the thread of the screw when made to the minimum pitch diameter. In testing, if the screw enters between the points, and the "Not Go" plug *D* does not, the screw is within the required limits for pitch diameter; any error in pitch is compensated for by the necessary reduction in pitch diameter.

### Indicating Gage for Inspecting Lead and Pitch Diameter

When the volume of work to be inspected warrants the additional expense, an indicating gage is to be preferred to one of the rigid snap type. A satisfactory indicating gage for testing the lead and pitch diameter of screws is shown in Fig. 31. This gage comprises a cast-iron base *A* to which is attached a fixed jaw *B*; the movable jaw *C* is attached to a slide *D*. Jaws *B* and *C* are each provided with two carefully ground and lapped vee projections, which fit in the threads of the screw being tested. The extreme ends of the points are removed, so that the projections will contact with the sides of the threads. The projections on blocks *B* and *C* are located exactly one inch apart and one set of points is offset from the other an amount equal to one-half the pitch of the thread being inspected. Slide *D* is kept in the forward position by an open-wound spring, and block *C* is withdrawn from contact with the work by handle *E*. Thus the pressure on the work being tested is that exerted by the spring that holds the slide in the forward position. When being inspected, the work is placed on the hardened and ground block *F*.

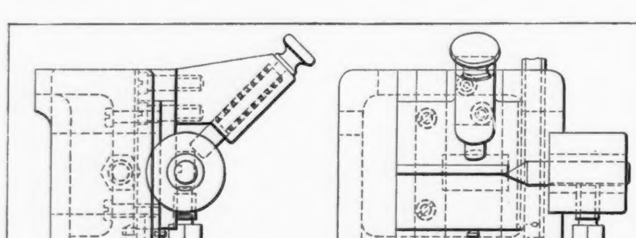

Fig. 30. Fixture for testing Lead of Opening Die Chasers

The indicating mechanism comprises two levers *G* and *H*. The short end of lever *G* contacts with the flattened face of a plug *I* on slide *D*.

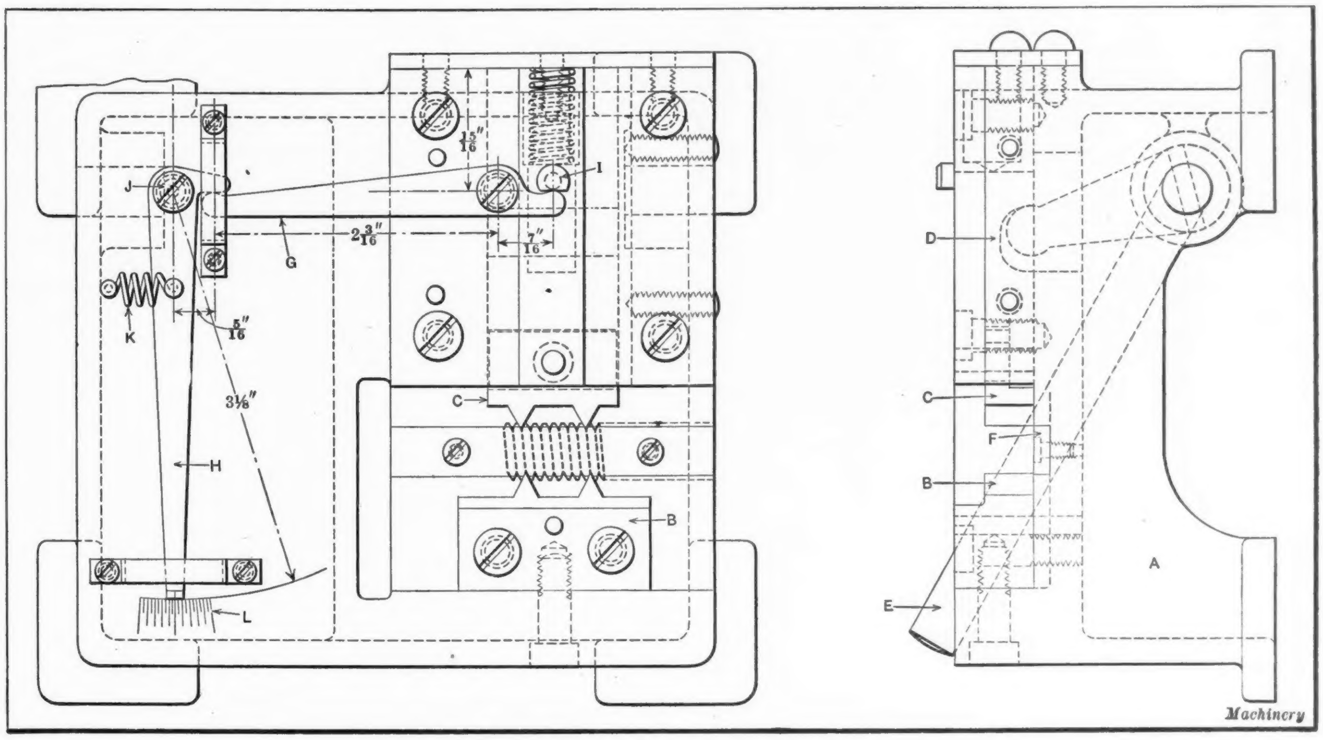


Fig. 31. Indicating Gage for inspecting Lead and Pitch Diameter

Lever $H$ is fulcrumed at the point $J$ and is kept in contact with the long arm of lever $G$ by a spring $K$. The ratio of the two levers, or the multiplication of the error, is 50 to 1, so that the marks on scale $L$ (which are spaced 0.05 inch apart) represent an error in the diameter of the work of 0.001 inch. With this device it is easy, therefore, to detect errors as fine as 0.00025 inch, although for the average run of work, this degree of refinement is unnecessary.

### Inspecting Die Chasers

The extensive use of opening die-heads for the production, in large quantities, of commercially accurate screws, has necessitated, in many plants, the use of fixtures for inspecting the chasers in order to insure that the pitch is within the desired degree of tolerance; also, in straight chasers, that the threaded face is correct in relation to the rear face. One simple but effective device for testing the lead of die chasers is shown in Fig. 30. This fixture was designed for testing the lead and registration of Geometric and Modern die chasers. It consists of a base carrying several slides that give the required movement and an indicator for testing the chaser. A chart is prepared for checking up the registration of the starting teeth on the chaser.

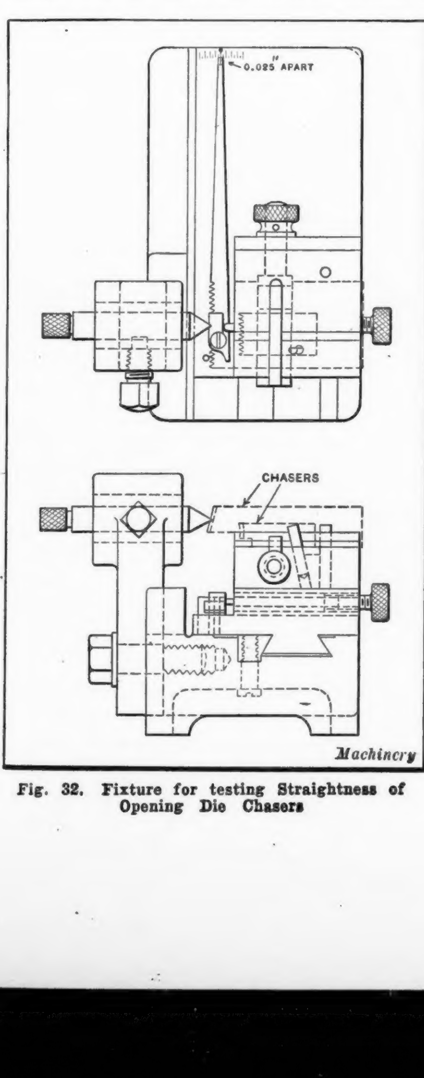


Fig. 32. Fixture for testing Straightness of Opening Die Chasers

In use, the chaser is located by the same slot that locates it in the die-head and, as shown in the illustration, is held in place by a spring plunger pressing upon it at an angle of 45 degrees. The top slide is located by a pointer which is held on a bracket, and meshes with one tooth of the chaser. The spindle of the dial indicator bears against the end of this slide. To test the chasers, No. 1 is set at zero on the dial indicator, and then the chart is used to determine if the other chasers are correct in relation to the first by noting the position of the needle on the indicator as each chaser is put in place.

Fig. 32 shows a fixture for testing the straightness of Geometric and Modern die chasers. In this case the chaser is also mounted on a slide, and a pointer, in connection with a multiplying lever, is used to indicate the distance from the rear face or slot to the pitch line of the chasers. The slide is adjusted to bring each tooth successively in line with the pointer, and then the movement of the indicating lever is noted. This lever is kept in contact with the slide so that any change in the position of the slide for the various teeth in the chaser is multiplied by the indicator. The lower slide is adjusted to bring the pointer in line with the various teeth of the chaser while they are being tested.

### Microscope for Measuring Screw Thread Gages

The micrometer caliper with various types of ball and cone points is satisfactory for testing the average screw thread. However, it is not sufficiently fine for testing accurate gages. The Schuchardt & Schütte precision measuring and screw testing microscope, shown in Fig. 33, is intended for making accurate measurements of small objects, and it is particularly adapted for measuring and


Fig. 33. Schuchardt & Schutte Microscope for measuring Screw Threads

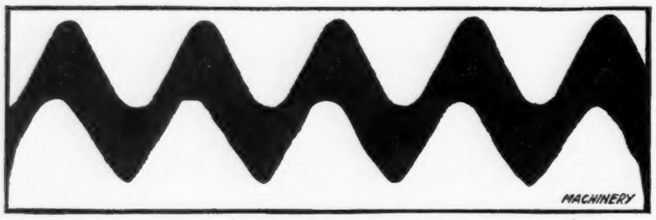


Fig. 34. Comparison of a Screw Thread (Below) and a carefully drawn Screw Thread Outline

checking micrometer screws, dividing scales, standard gages, and a variety of other precision work. The accuracy that can be attained with this machine is such that the length and pitch of a screw can be determined to within 0.00004 inch, the depth of the thread to within 0.0004 inch, and the angle of the thread to within 5 minutes. In making any or all of these measurements, it is not necessary to change the position of the screw or gage after it has been set.

Fig. 33 shows the instrument set up with a small screw in the chuck. In the field of the microscope are two cross-hairs which are used as reference points. In measuring the pitch of a screw, the vertical cross-hair is first brought exactly over the slope of the thread, and readings are taken. A screw is then manipulated to move the object across the field of the microscope until the cross-hair comes in visual contact with the slope on the next thread, and the readings are again taken. The difference between these two measurements represents the pitch of the thread. In measuring the depth of the thread, the horizontal cross-hair is first brought into visual contact with the top of the thread, and the readings are taken. The work is then moved until the horizontal cross-hair reaches the bottom of the thread, and the reading again noted. The difference between the two readings is the depth of the thread.

The field of the microscope can be rotated to provide for measuring the angle between the slope or sides of the thread. For making such measurements the field is rotated to bring one of the cross-hairs into contact with one of the angular sides of the thread, and the readings noted. The field is then rotated until the same cross-hair comes in contact with the opposite angular side of the thread. The difference between the two readings represents the included angle of the thread within an accuracy of five minutes. The object under examination may be inclined to the optic axis of the instrument and the angle of inclination determined. As the object remains in the same plane as the axis of rotation, it is not thrown out of focus by the inclination of the instrument.

### Projection Method of Measuring Screw Threads

A method of inspecting screw threads which up to the present time has not been extensively applied, but which for certain purposes (especially laboratory use) can be used with success, is the projection method. This consists chiefly in comparing a screw gage to be tested with a carefully drawn diagram magnified about fifty times. The gage to be tested is mounted on a suitable fixture, and is then illuminated by the aid of a small arc lamp and condenser. Carefully arranged lenses are then used to throw a magnified image of the thread on the chart or screen, and observations made on the diagram. The lenses should be chosen to produce a uniform magnification over the entire field, and distortion should be eliminated. As the screw carries a diagram of the thread which is magnified fifty times, it is an easy matter, as shown in Fig. 34, to compare the image projected with the correct thread profile. In Fig. 34, the image has been lowered somewhat to increase the depth of the shadow, and it can be seen that the thread on the gage is comparatively rough and incorrectly formed in places. Another method of comparison is to project, simultaneously, the image of an accurate screw placed beside the one to be examined. The difference between them is easily detected. This method applies to male gages and screws only, as it evidently would be impossible to project the thread in a ring gage or nut in this manner.

### Conclusion

In closing this review of the methods of gaging and inspecting screw threads, it must be admitted that this subject is far from being satisfactorily settled. There has been, however, an awakening on the part of manufacturers to the advantages of gaging methods properly applied and there is no doubt but that this subject will receive a great deal of study and investigation in the next few years. It is to be hoped that the results of these investigations will be published for the benefit of manufacturers in general.

* * *

## ELECTROPLATING GAGES FOR WEAR

One of the serious problems of interchangeable manufacture is the maintenance of gages. Obviously a gage, whether external or internal, begins to wear with the first piece gaged, and wear is continuous with use. The question is what limits shall be put on gage wear which, when exceeded, will require them to be returned to the tool-room for readjustment? If the limits established are very narrow, the cost of inspecting gages and restoring them to their original condition will be very heavy; and on the other hand, if the limits are wide, the gages will eventually become so worn that their usefulness as a means for maintaining standards will be lost.

The electroplating process presents a means by which gages may be restored to their original condition at a minimum cost. The process may be used also as a check on the wear by which any user will be apprised of the fact that the gage has worn below standard. Suppose a hardened steel plug gage is electroplated with a copper film 0.00005 inch thick. The total increase in diameter of the plug gage is then 0.00010 inch. Suppose we establish this as a limit of wear of the plug gage. Then the limit approximately is reached when the copper film is worn through and the hardened steel becomes visible.

The restoration of the gage to the original size is merely a matter of suspending the gage in the electroplating bath a certain number of minutes, the time depending on the thickness to be deposited, the voltage and other factors affecting the deposition of the copper. All these factors may be accurately determined and the electroplating battery may thus be employed as an accurate means of building up to exact size.

The objection to this system that doubtless will be urged is that copper is a soft material and wears rapidly, but a *thin* film of copper deposited on hardened steel wears comparatively slowly, as experience has demonstrated. The scheme is one that is worthy of earnest attention of gage-makers, toolmakers and others concerned with the manufacture, use and maintenance of gages used in interchangeable manufacture.

* * *

## COMMON SALT FOR PRESERVING WOOD

BY MARK MEREDITH [1]

Many methods are in use for preserving wood and preventing it from rotting. Most of these, such as chloride of zinc and the sulphate of copper treatment, are comparatively expensive, and are applicable therefore only to the better classes of wood; moreover, they can only be used by the large industrial works, and are not suitable for private use. It has now been discovered that ordinary common salt is an excellent substance for impregnating wood and for preserving it against decay. The effects of the action of common salt on wood were first noticed at the Great Salt Lake in Utah. It was observed that the sleepers of a railway line which was continuously washed by the very salt waters of the lake needed no renewal, and after forty-three years were in a far better state of preservation than oak sleepers impregnated with expensive chloride of zinc after fourteen years, when the latter required renewal. In consequence of this discovery, numerous and comprehensive experiments have been made to ascertain the effect of salt impregnation of wood, and it is reported to have been entirely satisfactory. It has been determined that a solution of common salt kills all the bacteria of decomposition and prolongs the life of the wood for practically an unlimited period. The discovery should have a tremendous effect on the wood industry, especially in connection with ships, railways, house-building, etc.

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# DIE-FORGING TROUBLES[1]—1

### FIELD FOR DIE-FORGINGS AND METHODS OF MAKING TO AVOID COMMON TROUBLES

BY JOSEPH HORNER [2]

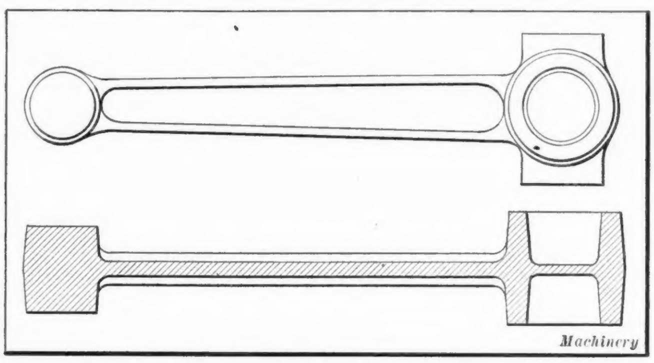



Fig. 1. Automobile Connecting-rod which illustrates Differences in Dimensions of Adjacent Parts

NOTWITHSTANDING the vast extension in the practice of die-forging during recent years, the results, in some cases, have caused disappointment. Many of the forgings have been found unreliable, likely to fracture, inaccurate while expensive, and lacking in the qualities of hardness, strength or toughness. Nor do these results cause much surprise to men familiar with the behavior of the ferrous metals and alloys. Many of these troubles arise from either ignorance or neglect; yet the purchasers are largely to blame for they often compare prices only. Sometimes the stampers are men who have not had the earlier and valuable training of working smiths; in other cases the heat-treatments suitable to the carbon and alloy steels are neglected.

Because it is always possible, under a hammer of sufficient power, to stamp any shape whatever from a white-hot piece of metal, the practice has grown of stamping many intricate and disproportioned shapes from a solid lump without the preliminary bendings, upsettings and fullerings that the smith

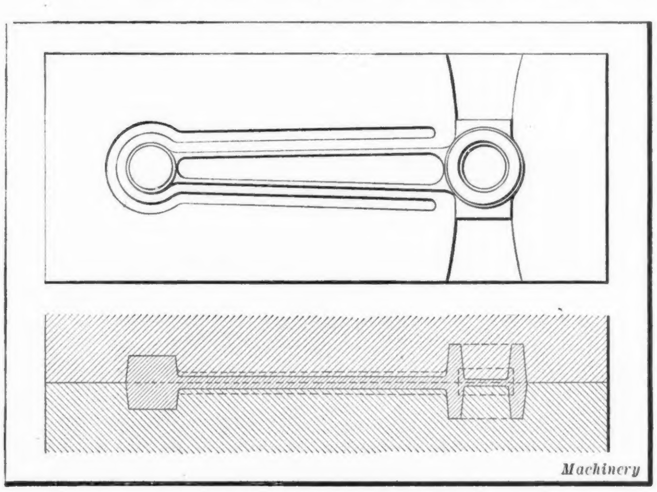


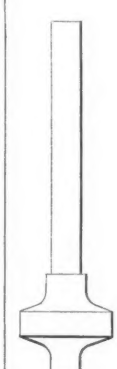

Fig. 2. Dies for forging Connecting-rod

performs at the anvil. Often this treatment is correct and economical, but frequently certain factors are ignored, such as fiber, proximity of heavy and light sections, deep ribs, sharp bendings and parts tied to each other without freedom to shrink. The smith at the anvil does not overlook these factors because early in his training he learned that such neglect will cause failure. Besides, he works largely in wrought iron, and wrought iron is just a bundle of fibers—crystals elongated by rolling—sometimes mixed with layers of dirt and scale, and the difference in strength with and across the grain amounts to several tons per inch. The same is not true of mild steel, though some fiber is developed by drawing, and in pieces where strength is required, direction of fiber should be taken into consideration.

Another cause of trouble is the large and rapidly growing use of the numerous kinds of alloy steel. There is no lack of information concerning the heat-treatment of these, but this treatment is frequently ignored, being regarded as a matter of lesser importance or one which involves too much trouble and labor. Alloy steels which are suitable for one class of forgings are unfitted for another.

#### Comparison of Forgings of Malleable Cast Iron and Steel Castings

Much the same conditions obtained when malleable cast iron and steel castings were first used. Adjacent parts were im-



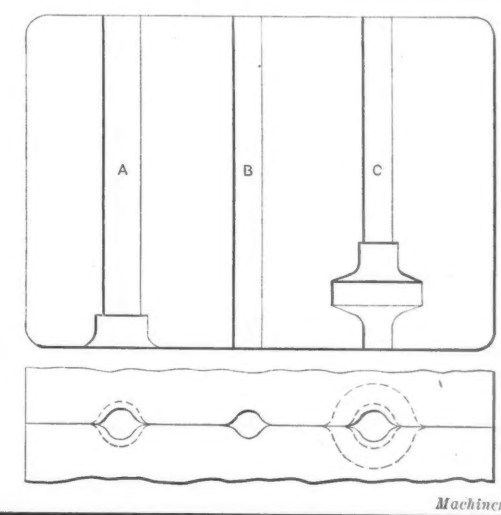



Fig. 3. Valve Stem

Fig. 4. Dies for forging Valve Stem

properly proportioned, the effects of shrinkage stresses were not sufficiently appreciated, and heat-treatment (annealing) was imperfectly done. As a result both malleable iron and cast steel were tried and then discarded for a long season. Nor has the prejudice against steel castings been wholly removed. There seems to be no difficulty in obtaining heavy steel castings that are sound and to dimensions, but relatively few firms have equipped themselves to provide small castings, of a few ounces or pounds weight, that are sound, have minimum allowances for machining, and are of correct uniform thickness and homogeneous throughout. Firms who must have these may find it profitable to install a small converter plant, and by experimenting, find the solution of this problem. There are many parts now commonly forged, of which levers are typical examples, for which sound steel castings would be as suitable; perhaps more so in some cases, because castings possess greater rigidity.

The subject of forgings versus castings is a live one. Forgings are frequently more homogeneous than castings; that is, they are free from blow-holes, a matter of much importance when tooling has to be done. Hard spots and blow-holes play havoc with delicate tools. Besides, cored castings are very likely to turn out with unequal and variable thicknesses and this increases the difficulty and cost of machining. This lack of uniformity in thickness is of great importance because of

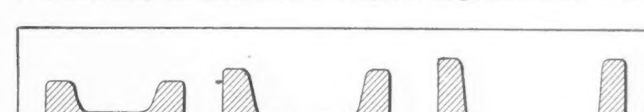



Fig. 5. Stages of Lever Forging

[1] For information on drop-forging previously published in MACHINERY, see "Impressions for Bosses on Drop-forgings," November, 1913; "String Drop-forging," December, 1912; "Dies for Drop-forging a Crankshaft," October, 1912; "Making Duplicate Drop-forging Dies," August, 1911; "Drop-forge Die Sinking," July, August, and September, 1911, and articles referred to in connection with the first installment.

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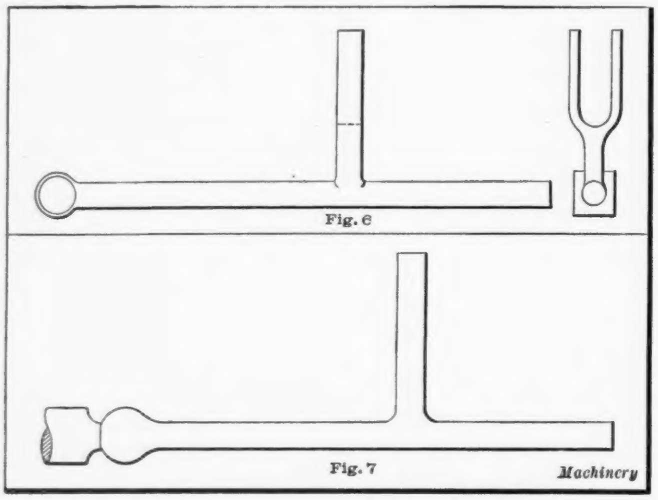



**Fig. 6. Making a Wrought-iron Rod with Fork at Right Angles**
**Fig. 7. Completed Steel Rod**

the growing practice of holding pieces of repetitive work in jigs and fixtures. The facility with which this is done is hindered by variations in the dimensions of the pieces. This trouble often determines a decision in favor of forgings over castings. In addition, when dimensions are variable they are uncertain. Corresponding parts that are thicker in one casting than in another, require tedious readjustments of give-and-take settings. These are expensive to make and are frequently rejected, after some of the tooling has been done.

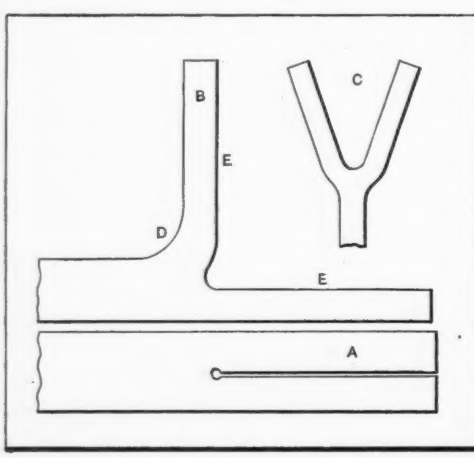



**Fig. 8. Making a Steel Rod with Fork at Right Angles**

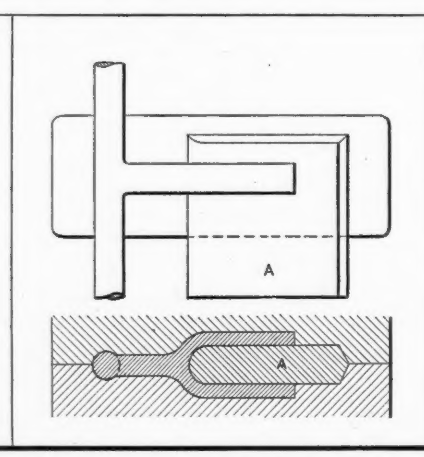



**Fig. 9. Dies for Forked Part of Rod**

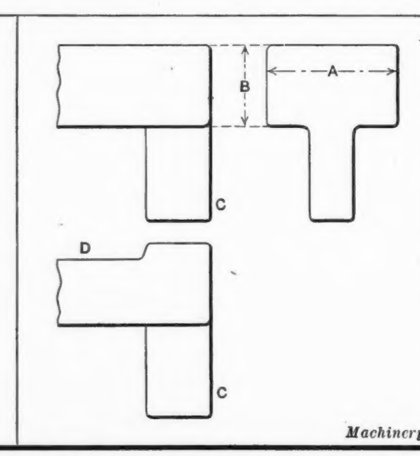



**Fig. 10. Forging Boss from Rectangular Rod**

Malleable cast iron suffers by comparison with cast steel, because its tensile strength, rigidity, and hardness are lower. It is therefore not a desirable material to use for levers, or indeed for any parts that are subjected to severe stress and wear. But it is suitable for hubs and for axle-gear cases and similar parts. Good malleable castings are the result of a careful grading of iron, in the first place, and an equally careful annealing. It is for this reason that deliveries must always be delayed from three to four weeks after the castings have been turned out of their molds.

Die-castings have not competed seriously with forgings, or with castings in steel and in malleable iron. Being made of soft alloys, they are not suitable for parts that require much strength or are subjected to rapid wear. They are cast to fine limits of dimensions and are beautifully finished, but until they can be produced in the harder materials they cannot compete with die-forgings.

### Troubles Due to Difference in Dimensions of Adjacent Parts

Considerable fault has been found with some classes of die-forgings, but a study of the reasons for the defects will show the evils that ought to be avoided. The study, however, should begin with the ordinary products made from mild steels, for the difficulties are accentuated when alloy steels are used.

The principal troubles that arise, and that are fruitful in evil results are, first, large differences in the dimensions of adjacent parts, deep sections, and acute changes in direction, as sharp bends or offsets. In a sense these are related to each other, because in each case the proper treatment is related to the character of the material being molded. When heated to nearly the welding temperature, steel is plastic; that is, it flows and takes the course of least resistance—develops something of a fibrous character. Yet it offers internal resistance to forces acting upon it, and is over-stressed if these forces are excessive. Some of the lesser stresses may be removed by subsequent annealing, but they may be of too violent a character to respond fully to such treatment. The anvil smith understands these facts and brings his practice into harmony with them. He cannot well injure a forging that is being shaped on the anvil, but harm may easily result under the blows of a power hammer or the squeeze of a press. The injury, therefore, which metal often suffers in mechanical forging is seldom inflicted at the anvil.

In many instances where welding would be the method selected as suitable at the anvil, the article is stamped solidly and weldless under the drop-hammer. This is often better for the forging, particularly when it is made of steel, which does not weld quite so reliably as iron. But on the other hand, to stamp from the solid may result in the production of a weak forging because of short fiber. This, though a nearly negligible fact when mild steel is being used, is of importance when wrought iron is under treatment; indeed with the latter material, slender parts must often be bent and forged or else attached to adjacent parts with welds.

Differences in the dimensions of adjacent parts may seriously

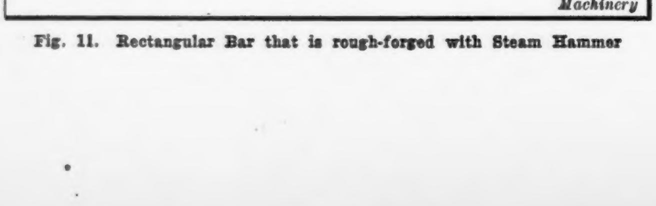



**Fig. 11. Rectangular Bar that is rough-forged with Steam Hammer**

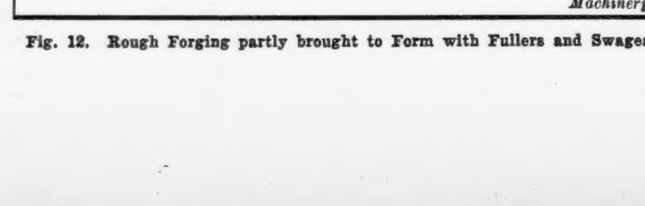



**Fig. 12. Rough Forging partly brought to Form with Fullers and Swages**

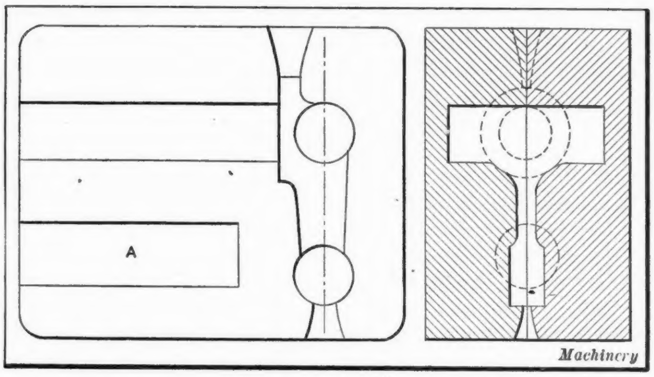



Fig. 13. Finishing Dies for Piece shown in Fig. 12

diminish the strength of forgings in which they occur. Take, for example, an automobile connecting-rod, Fig 1, which has two solid lumps at the ends, connected with a relatively slight web or shank. The web must be reduced—drawn down from a lump which is somewhat larger than the dimensions of the larger capped end. This forging is also typical of many double-ended levers and similar objects, and when the material is of a fibrous character, its quality is improved by the work done upon it at a white or a full red heat. When such articles are produced at the anvil, the thin connecting web is reduced gradually, without suffering injury, by the gentle operation of fullering. When a power hammer is available, the fullering is often done under that, the tup taking the place of the sledge. In each case the reduction is gradual and the metal is not stressed.

in the central planes of the bosses and of the web. This increases the cost of the dies, but it improves the product and leaves less metal to be removed by trimming.

### Forging Hole in End of Connecting-rod

Another problem in the making of a connecting-rod is the forging of the hole in the big end. The part which is to become the cap is forged solidly along with the big end bearing, and a hole is punched to avoid the cost of drilling and boring through solid metal. Punching this hole displaces a large amount of material and is another possible source of weakness. In roughing out the head, its dimensions measured across are left rather less than those of the finished head to allow for the enlargement which results from punching the hole. As shown in Fig. 2, this is done with punches, which form a part of the dies themselves, standing up for nearly one-half the thickness of the boss from each die. They must not meet or there would be no space left for the fin from the hole, which must occupy the space between the halves of the punch. The operation of punching squeezes the surrounding metal outward to fill the die and to form the outside parts of the big end. Another method of forming the hole is to lay the end in a bolster and punch the hole all the way through with a punch that will clear itself. The punch may be gripped in a withe or laid on the forging and driven through by the tup.

When work is enlarged by punching in dies, the metal is stretched and may be opened out, which is not good for it. To avoid this, the allowances should be so proportioned that the outward pressure exerted by the punch will be counteracted by the sides of the die so that the metal will be sub-

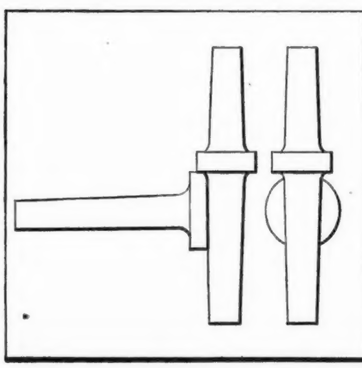


Fig. 14. Forging for Steering-axle Arm

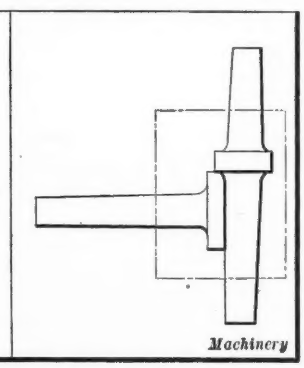



Fig. 15. Relative Sizes of Forging and Material used

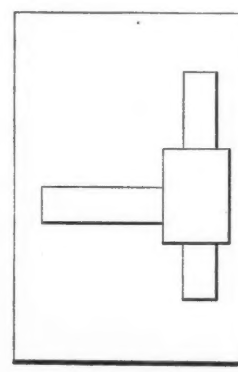


Fig. 16. First Reduction in forging Steering-axle Arm

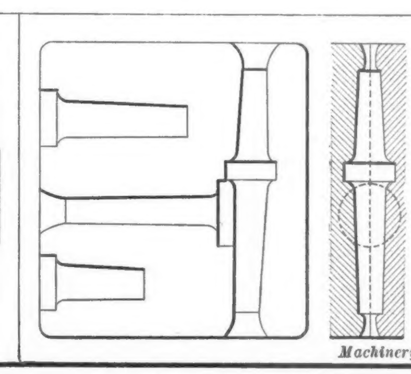



Fig. 17. Dies for forging Steering-axle Arm

In marked contrast with this are the results obtained by stamping the same article from a solid lump between dies in one operation. A large quantity of metal is suddenly displaced from the web portion, flowing out into gutters and setting up intense stresses in the places where the thinner metal joins the heavier. This trouble might be avoided by adopting the methods of the smith and making the process a gradual one. This can be effected either by employing more than one pair of dies or by doing some preliminary work at the forge. Each is equally suitable, but when a hammer is available it performs the work more rapidly than the anvil tools. The preliminary reduction can be made by the employment of a fullering tool held in the hand, and moved over the lump on the anvil and struck by the tup; or breaking-down dies may be used; or a very rough reduction can be made in the finishing dies, recesses having been cut in the sides for this purpose. The last method is quicker than fullering with a round-faced tool and cheaper than separate dies for breaking down. This roughing down is done at the side of a die in order to have room for the spreading out of the displaced metal. The forging, after breaking down, is still a mere shapeless lump of metal, but it has undergone its maximum amount of reduction. It may then be finished in the die impressions which impart its final outlines.

When the connecting web is plain instead of recessed, a good plan is to pass the forging through two sets of dies, divided in planes at right angles, the roughing dies being jointed through the axis of the bosses and the finishing dies

jected to pressure between the punch and the die. It is better that an excess of fin should be thrown out in this operation than that the metal should barely fill the die when finished.

When the best results are desired—exact dimensions, freedom from stress, and good finish—the forging should be finished in a second pair of dies. The connecting-rod forging must be first put through stripping dies to remove the fins, reheated, and restamped in the finishing dies. Unless large numbers of rods are being ordered, it is almost better not to punch the holes, but leave the end solid to be drilled, which simplifies the dies, as no projections for the holes are needed.

### Forging Articles with Deep Sections

The case of articles having very deep sections, such as large bosses and ribs, is nearly parallel with that of articles having

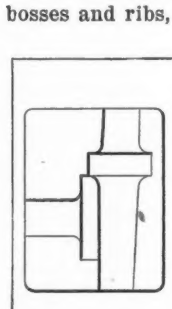


Fig. 18. Dies for Formative Work

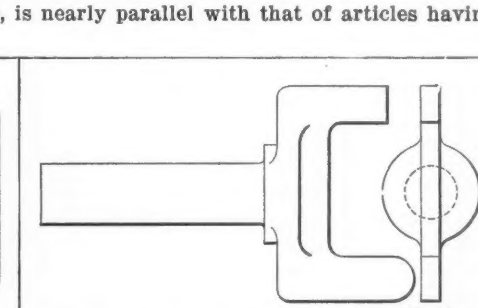



Fig. 19. Forked Forging on which Breaking-down is Necessary

heavy and light sections adjacent. In each case, the metal is distressed by severe work done upon it unless the drawing is done gradually. Bosses on levers and on deep forgings, such as hubs, are troublesome to draw at one heat. In the case of levers the web should be fullered down on the anvil or under the hammer as a preparation for the finishing dies. The reduction can be done either with a fullering tool or in a breaking-down die, the choice depending generally on the number of pieces required.

The larger the dimensions of the forging, the more necessary is the preliminary reduction. In small articles the omission of a preliminary reduction does not matter much, because the smaller mass of metal flows more readily than the larger one, though the relations of thick and thin parts in both small and large castings may be alike. Yet, in good practice, the smallest articles which have much discrepancy in adjacent dimensions are treated in two or more die impressions at one heat in the same dies—breaking down, finishing, and stripping. On the other hand, only a portion of a large forging may be finished in dies. The bosses only may be thus treated, with a small length of the web adjacent, the remainder of the web being finished with a flatter, or under the plain tup of the hammer. A large volume of heavy work is done in this way. Much of this work is also being done in the forging press.

The valve stem shown in Fig. 3 requires preparatory reduction if the valve and stem are formed in one forging; being a small piece it can be dealt with at one heat in one pair of dies. The stem and valve head are roughed down in two successive swaging recesses *A* and *B*, Fig. 4, leaving the valve

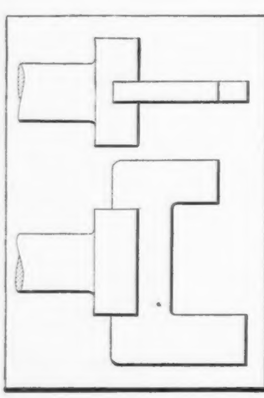


Fig. 20. Work shown in Fig. 19 after First Drawing

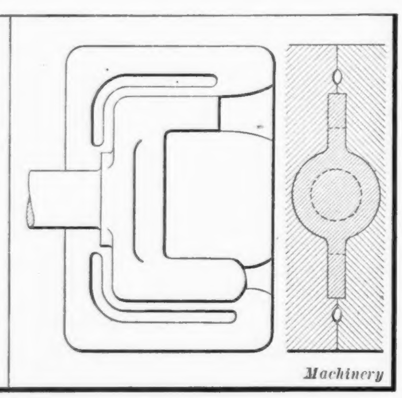



Fig. 21. Dies for making Forked Forging shown in Fig. 19

portion thicker or thinner, according as the intention may be to enlarge or reduce its diameter in the final finishing impression *C*. No stripping dies are necessary in this case. The fin is eliminated as soon as it is formed by rotating the forging in the dies. This is readily done by forging from a bar long enough for the other end to be used as a porter.

Deep ribbings on webs of levers, Fig. 5, are another source of trouble. Being made, as these levers must be, from a flat bar of simple rectangular section, the pressure required to produce the shape is very severe. To attempt to impart the final section in one heat would necessitate raising the metal to a temperature that might injure it and shorten the life of the dies. If the work is done in successive stages, as shown at *A*, *B*, and *C*, no damage will result because the reduction and the formation will be so gradual. This is the principle applied when rolling steel beams and channels.

### Forging Pieces with Sharp Bends

Acute changes in direction, as sharp bends, are found in a large number of forgings. Obtuse angles are tolerable and right angles are bad, but acute angles are a danger. Yet even these last entail no risk if the forgings are made in the correct manner. The controlling factors are the kind of material used, the methods of formation, and the use of connecting radii.

It is always well to regard this class of forgings from the point of view of the smith working at the forge in wrought iron. His method is either to bend adjacent portions or weld

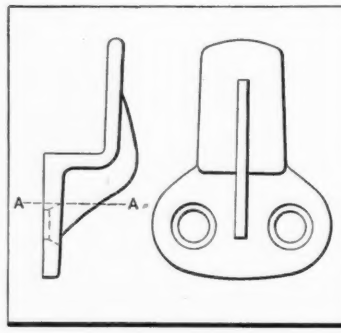



Fig. 22. Hatch Cleat to be forged

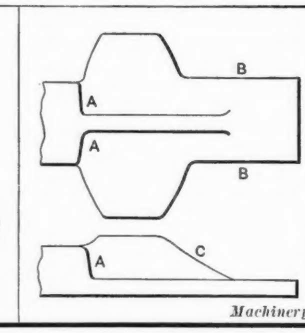



Fig. 23. Metal when reduced by Hammer

them; rarely does he attempt to cut out such articles from the solid, regardless of the direction of the fiber. He may do so when dealing with mild steel. He does this partly to preserve the fiber intact in the longitudinal directions, to lessen his labor, and to economize material. But none of these reasons appeals with much force to the die stamper, who is therefore disposed to stamp many articles from the solid which an anvil smith would bend or weld more slowly and more laboriously. As a result, levers with sharp bends are frequently untrustworthy in service. The characteristics of malleable materials are not appreciated so fully by the die stamper as they are by the smith.

On the other hand, steel will endure bendings of a much more severe character than wrought iron will, but it is less reliable than iron when welded. Between these two evils the stamper must take his choice. Aside from unusual cases, welding should be regarded suspiciously in steel, but it is not always unavoidable, and is not so risky in the mild steels as it is in the high-carbon and many of the alloy steels.

In each of the following examples of forgings with sharp offset pieces, a smith working at the anvil would generally adopt welding methods; in steel this welding would not be adopted. The rod shown in Fig. 6, having a fork extending out at right angles, is one of those jobs that may be made with or without a welded joint. The use of this joint would unquestionably be the better method for a forging made in wrought iron. Then the rod can be easily made by preparing the forked piece and uniting it to the rod either with a scarfed joint or a vee. A slight preliminary upsetting of the end to be scarfed would be required and a slight enlargement, by upsetting, of that portion of the rod in the vicinity of the weld. The same method might well be adopted in the case of mild steel. But another way, and one in which welding is avoided, is to fork and bend from a straight piece of rod, as indicated in Fig. 8. The method entails a considerable amount of reduction, but that is a negligible matter when it is done under a power hammer. The bar selected must be large enough to permit of the formation of the two parts *E* of the fork. These prongs are divided with a hot set, as shown at *A*, and opened out to a right angle as at *B*, leaving a good radius behind at *D*. The piece bent round is then divided similarly, and opened out, as shown at *C*, and hammered to approximate shape on a form. The rear part of the rod is drawn down next, nearly wholly on one side, either by fullering or directly between the tup and anvil as far as the boss portion, which is left nearly the original size of the bar as shown in Fig. 7.

The forging, however, need not be completed wholly in dies; being of considerable length, the dies would be inconveniently

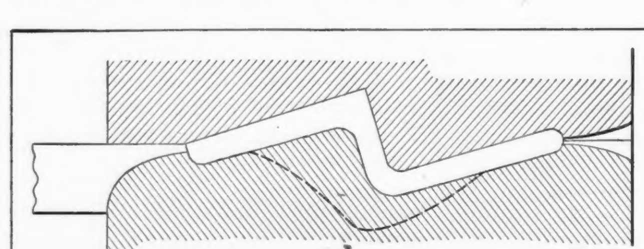



Fig. 24. Dies for dummying Hatch Cleat

massive. It is enough to finish the central part in dies, Fig. 9, and the bossed end in another pair, leaving the stems to be completed neatly in common swages. The top die is removed in the upper part of Fig. 9.

By proceeding in this way, the continuity of the metal is preserved without doing more injury to it than steel can endure. The special precautions which are necessary are to avoid too quick a bending at *D*, Fig. 8, and to punch a small hole when splitting down, as at *A*. Even though a keen angle may be required in the finished forging, it must not be formed in the first place. A large radius or fillet must be left, and the larger the safer; it is easily obliterated in the subsequent forging operations. If this precaution were always taken, there would be fewer complaints of the fracture of forgings of this kind.

This preliminary work is more readily done on the anvil than in dies, and the die-forging, if the numbers justify the outlay, should be performed in two sets of dies, thus relieving the finishing dies of the rather large amount of reduction that would otherwise be necessary. By concentrating the work in one pair, the metal is stressed rather severely and the forgings are of unequal dimensions and variable weights, because the amount of fin squeezed out is

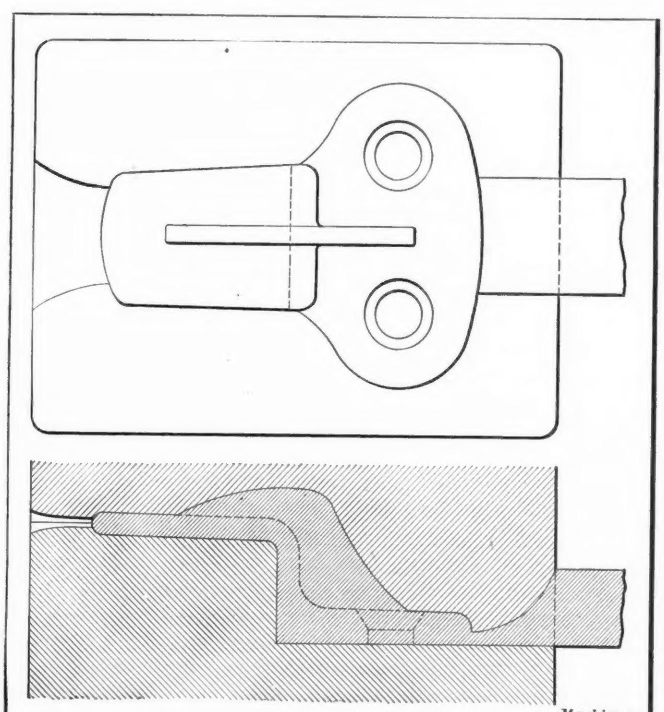



Fig. 25. Dies for finish-forging Hatch Cleat

unequal, as the joints of the dies are thrown apart to variable distances by the fin, which cools and sets quickly. Though this fin is subsequently stripped the forgings are left of greater depth than they would have been if the dies had closed on the joint. But the method to use also depends on the degree of accuracy with which the preliminary work has been performed. In cases, like Fig. 9, where there is a forked end, the fork must be molded over a form block *A* let into the dies. If the fork is of small dimensions, it is generally better to forge the part solid and slot or mill it out in the machine shop.

In the case of a forging like that shown in Fig. 11, where the metal is rather heavy in the locality of the large boss, it is always better to take a rectangular bar large enough to draw down from than to select a smaller one and upset it. The latter method should be avoided when practicable, because it tends to open the fiber. For drawing down, the shape of the original piece, whether square or cylindrical, is of no particular moment, the point being to reduce smaller sections from large ones. In the present case, the forging is made from a piece of metal which need have no particular relation to the finished work. It is best taken, as in Fig. 10, about as thick in one direction as the distance *A* over the bosses, and

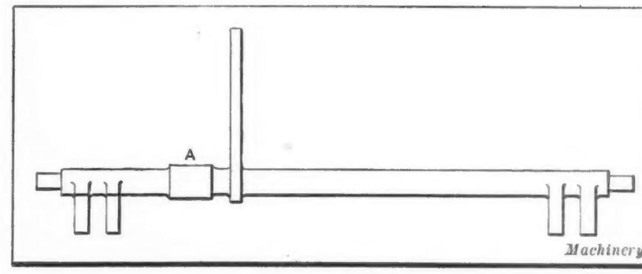



Fig. 26. Weigh Shaft

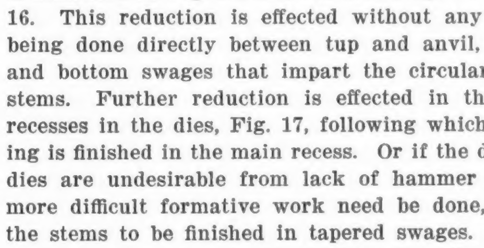
in the other wide enough to include the boss *B* and the arm *C*. Its length must be sufficient for the stem *D*.

The rough dummying may be done under the steam hammer between tup and anvil, bringing the lump first into the shape shown in the upper part of Fig. 10, and then into that shown in the lower part. Material is drawn down to one side *C* to form the arm, and set down on the other side *D*, after which the stem is drawn out and rounded roughly. The roughing out is continued to form the outlines in Fig. 12; this is done with fullering tools at *A* and with swages at *B*. After cutting off the angles with a hot set, the forging can be finished in dies. These dies are shown in Fig. 13. The recess *A* is used for bringing the stem nearly to the correct size and outline before the final forging in the main recess. The extension of the stem serves as a porter bar, which is severed subsequently with a hot set. The open end of the die permits of the extension of the stem as its diameter becomes reduced. The fin formed at the other portion is squeezed out through the gutters shown. A stripping die may be made or the forging can be taken out by the porter bar and the fin knocked off and replaced for finishing at one heat.

### Forging Shapes by Making Large Reductions

The steering-axle arm forging, Fig. 14, is one that would be bent or welded by an iron smith. But as pieces of this kind are always made in steel, and generally in one of the alloy steels, the question of direction of fiber is negligible. Bending and opening out might be done in steel in this case, but it is hardly practicable, because of the collars about the central parts. It is better to take a cubical lump and effect the shaping by reduction. The relation of the lump to the forging is indicated in Fig. 15, and the first stage of reduction in Fig. 16. This reduction is effected without any help from dies, being done directly between tup and anvil, followed by top and bottom swages that impart the circular outlines to the stems. Further reduction is effected in the supplementary recesses in the dies, Fig. 17, following which the entire forging is finished in the main recess. Or if the dimensions of the dies are undesirable from lack of hammer power, only the more difficult formative work need be done, Fig 18, leaving the stems to be finished in tapered swages.

The forging shown in Fig. 19 is made with some preliminary breaking-down from a piece of rod considerably larger than the diameter of the boss. From this, the forks and the stem are produced by drawing. The general plan is shown in Fig. 20. The material is drawn down at the sides and at the front, forming a plain extension large enough to include the horns. The superfluous metal is cut out with a hot set. At the rear,



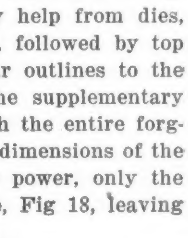




Fig. 27. Welding Large Lever to Weigh Shaft—Lever embracing Shaft

Fig. 28. Lever with Scarfed Joint

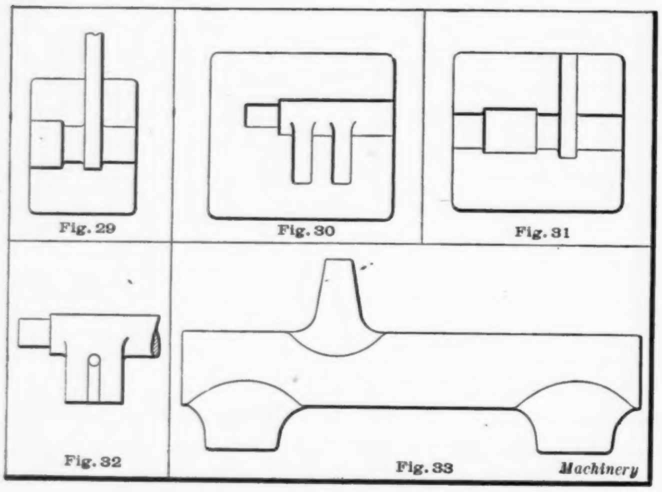



Fig. 29. Dies for forging Lever of Weigh Shaft
Fig. 30. Dies for forging Ends of Weigh Shaft
Fig. 31. Dies for forging Large Lever and Enlarged Part of Weigh Shaft
Fig. 32. Removing Metal from Interspace at End
Fig. 33. Forging Steel Weigh Shaft

the stem part is swaged down. Finish can now be imparted in dies to the boss and forks, leaving the stem to be finished in common swages. The dies are plain, as shown in Fig. 21. Stripping dies may be made, or the forging can be pulled out by using the stem as a porter, the fin being knocked off, and the forging returned for finishing. In neither of these examples is injury done to the material, nor is there any risk of incipient cracks nor of faulty welds.

These preliminary reductions need not all be done at the anvil; all the fullering is performed much more rapidly under a power hammer. One or two minutes will suffice for any of the fullerings here mentioned, and the forgings will generally then be hot enough to be put through roughing dies, if such are used, and stripped, but a second heat will be required for finishing.

### Forging Awkward Shapes

The hatch cleat shown in Fig. 22 has no great differences in adjacent dimensions, but the shape is an awkward one to forge by hand under the steam hammer. It is properly a job for drop-forging, which offers no especial difficulties; but the dummying may well be done, without help from dies, under the power hammer. It includes two processes, roughing out the two parts at right angles—the plate and rib—and beginning the bending. The best way to make this cleat is to take a bar or a lump having a cross-section about equal to that of the total area across the widest part *A-A* of the forging and spread the metal out under the hammer, as shown in Fig. 23. The bar should be turned about at right angles under the hammer to deliver a few blows on the flat part and on the rib alternately, spreading both out with a reduction of thickness. This can be done, without any aid, by laying the bar toward one side of the anvil, so that the corner of the tup and adjacent edges will strike in the corners *A*, where the reduction begins. Simultaneously, the sides *B* will be narrowed—not by cutting but by drawing down under the hammer—and the slope of the rib at *C* also imparted similarly, the forging being turned about rapidly so that all the reductions will be made alternately and in succession, in one heat.

Two dies that may be used for this purpose are shown in Figs. 24 and 25. The first is better for facility of forging, but it will not form the screw holes, which the second will do. As an alternative, the first may be used for dummying only, leaving the finish and the holes to be done in the second. The top die is removed in the upper part of Fig. 25.

### Forging a Weigh Shaft

The weigh shaft, Fig. 26, is a job for welding if made of wrought iron; if made of steel it may be welded or forged. Welding may be used in the case of mild steel, but if the piece has a large carbon content, and with some alloy steels, welding is not desirable. Then the alternative entails a large amount of drawing down. This is a problem that arises often in shops where hammer power is limited. A smith knows almost as if by instinct, how much his hammers are capable of doing, just as a man working at the anvil only, knows the limits set to hand work with fullers and swages. Insufficient power often causes the adoption of methods that would not be followed or even considered if more power were available. It often means the selection not of the best possible method but of the most practicable. Heavy reductions, though not impossible, are tedious and expensive if done at the anvil or under light hammers. The alternatives to reduction are, then, upsetting, which is limited to small areas, and welding, which is the chief alternative and practically the only one. As long levers with offset pieces are a common type the methods outlined are suitable for work in iron and in steel, both those employing welds and those dispensing with them.

In the method which is best adapted to include welding, a rod of the same diameter as the shaft is taken and the lugs and the lever are welded to it. The slight enlargement at *A* is made by taking a short heat there and upsetting, the bulbous formation that results being reduced in swages. The pins at the ends can be reduced in swages.

The strongest way in which to weld the lever is to make it embrace the rod, as shown in Fig. 27. A scarf, butt, or vee weld should not be used as the surfaces in contact are narrow and it is not desirable to encroach into the rod. An encircling weld gives a large surface; it was formerly much used in welding the webs of wrought-iron cranks to the shafts and pins. To make this weld, the lever is cut and forked, as shown at *A*, and bent around the shaft, as at *B;* a welding heat is then taken over the section and the joint closed with a hand hammer or in swages. The necessary reduction and finish are imparted in swages or dies, which should be made especially to embrace the entire section, force the sides together, and complete the outlines without leaving any correction to be made later.

The short levers near the ends can be welded on, each pair of levers as one piece to be subsequently divided in a slotting machine or with a saw running down to a drilled hole. A scarfed joint, shown in Fig. 28, is most suitable for this place and is preferable to a vee or a butt. The bar must be slightly fullered over the area to be welded, and the lump for the lever will be slightly upset or spread out by fullering in the manner employed in connection with weld joints.

If dies are used for imparting finish, two only need be made, one for the central part—that about the lever, Fig. 29—and one for the two ends, Fig. 30. If the dies shown in Fig. 31 are employed, the preliminary swaging of the enlarged part can be omitted, since the dies embrace the whole of that part of the shaft. The same pair of dies made for one end of the shaft, Fig. 30, will serve for the other. They are shown with the forks out instead of leaving them solid for the machine shop to deal with. This is the better method when dies are used. The metal can be removed from the interspace, in the smithy, by punching a hole at the bottom, as in Fig. 32, and cutting down to it with a hot set; but a neater and less severe method is to punch or drill a hole and saw down to it. If the hole is to be punched, it may be done at the same heat as the welding, using a hand punch with a withe.

If such a shaft is made in steel, which is not so well suited for welding, Fig. 33 shows how it may be made from a solid bar, but at the expenditure of a large amount of labor in reduction. A bar of large dimensions is fullered down heavily at three sections, which correspond with the long lever and the two pairs of forked levers. The distances these are apart are so estimated that when the shaft is drawn down they will occupy roughly their centers on the finished shaft. Consequently, as exact accuracy is not possible, the fullered portions are left as roughed in Fig. 33, until the shaft is brought to its proper diameter and length. Then the formative and corrective work is done upon the lever parts. The amount of formative work entailed is large. Much of it must be done with fullering tools, though some truing is done with sets. More will be saved then by making the final correction in dies similar to those already shown. Roughing and finishing dies may be employed, or one pair of dies with one or two removals to knock off the fin.

### Removal of Fins

In all examples of the class of forgings just mentioned, the quantity of fin removed is very large, so stripping dies are desirable. If the attempt is made to forge without roughing dies, the fins must be knocked off with a hammer as they are formed or the forging removed to the stripping dies, and then returned to the forging dies once or twice before the work is completed. In this case, the forging may have to be reheated.

Fins are not only unavoidable but, in moderation, they are desirable because they prevent the damage to the dies which would result from the violent collisions of their faces. They form an elastic cushion between these faces. If expressed in large quantities, as must happen in some forgings or sectional parts of forgings, they are removed once, twice, or three times in successive reductions until that left is very thin. If a thick fin is left at the final correction, the forging will be too thick and over weight. This is often a cause of complaint against drop-forgings and is objectionable because it increases the labor of tooling and interferes with the practice of tooling in fixtures when that method is adopted.

Only when objects are wholly cylindrical in section can fins be reduced as soon as they are formed, by rotating the work in the dies between the hammer blows. In all other cases the forging remains in one relation to the dies and the fin is squeezed out in the joint without being reduced at all. Consequently some spaces must be provided into which the fin will flow. As the faces of the dies at the joint must make actual contact, the provision for the fin is made in a direction away from the jointing edges of the dies. It often comprises a joint, sloped to receive the accumulation of fin. As this leaves only a narrow margin of actual joint faces, the gutter is often preferred. This is a good method to adopt when large amounts of fin are being squeezed out. The gutter is brought moderately near the edges of the die, leaving narrow flat faces between it and the die, and also beyond it.

Associated with these methods, or independent of them, is the common practice of sloping away the faces at the joint where the forgings terminate at ends or at sectional parts. This permits of the flow of metal in large quantities without any obstruction. Enough of an opening must be left for the superfluous metal to get away freely, without too sudden chilling and setting. The same provision often serves for severing the forging from a porter bar, the narrow zone of metal serving like a nick to break off the forging from the porter. The thinning of the fin, generally at the front edges, also enables the stripping to be done easily. It is often knocked off with hammer blows, though stripping dies are better and should be used when the quantity of forgings is large.

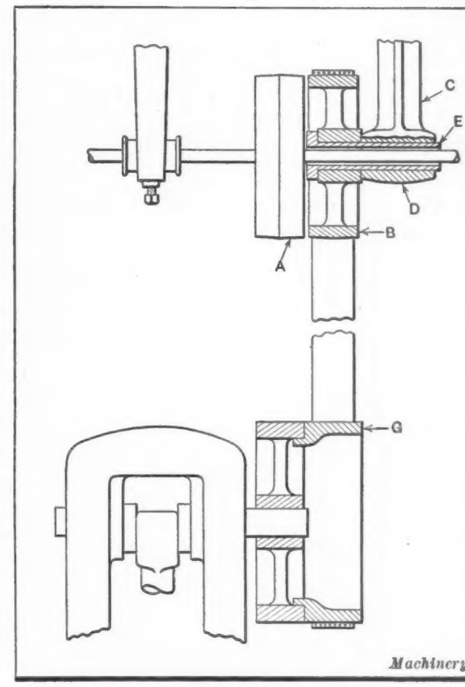
To allow a large quantity of fin to be expressed from forgings is not considered good practice, but there are many exceptional cases where it should be done, especially in the case of very irregular and awkward shapes. It may be true economy when the alternative would entail a large amount of formative work at the anvil, or under the hammer with fullering tools, sets, and swages.

* * *

## PRESS-ROOM LINESHAFT IDLER PULLEY

The bugbear of most press-rooms is the throwing off of power press belts to stop the press while the tools are being changed or when the press is not to be used for some time. Where the state law does not forbid it, it is often the practice to throw a power press belt off both the pulleys, and tie a knot in it, allowing it to hang from the lineshaft. This is dangerous, and unsightly as well. In states where the law forbids this practice, a clutch is generally employed. This may or may not be satisfactory, according to the kind of clutch used, and the equipment is rather expensive.

At the plant of the Frank Mossberg Co., Attleboro, Mass., the idler pulley construction illustrated was developed and is being used with marked satisfaction. In view of the difficulty experienced with an ordinary loose pulley on the constantly revolving lineshaft, this improved pulley construction was designed. The pulley $A$ is of the ordinary split type and is fixed to the lineshaft. Besides the regular lineshaft hanger shown, another hanger $C$ is introduced which is provided with a cap $D$. The cap clamps the split bushing $E$ on which the loose pulley $B$ is mounted. Pulley $B$ is also of split construction. About 1/8 inch clearance between the split bushing $E$ and the lineshaft is provided, thus relieving the lineshaft of the pull of the belt when idle. A ring $G$ is attached to the flywheel of the press which forms a pulley of sufficient width to permit shifting the belt to the "off" position. The split construction of all the parts in this idler pulley permits it to be erected or taken down without dismantling the lineshaft. V. B.



Press-room Lineshaft Idler Pulley

* * *

## OUR COPPER INDUSTRY

With the entire output of the first half of this year sold some time ago, copper producers are working every available source of supply to the limit. As a result, the production of copper in the United States is 700,000,000 pounds a year more than it was in July, 1914. Then the metal was mined at the rate of 1,700,000,000 pounds a year and was sold for 13.75 cents a pound. At the beginning of this year, it was produced at the rate of 2,400,000 pounds a year and was sold for 35 cents a pound, though the average price for the year was 27.2 cents a pound. Because of this increase in value and in production, nineteen of the largest copper companies in the country paid $77,500,000 more in dividends in 1916 than they did the year before. This increased value also made it possible to work sources that could not be properly developed two years ago.

While in time of peace only about one-tenth of the copper produced throughout the world is used for the manufacture of war materials, at least three-fourths of the present immense production is used for war purposes. In addition, the 100,000,000 pounds annually produced by Germany, Austria, Turkey and Serbia are used in the war. However, should the war suddenly end, the demand, and hence the price of copper, would not immediately drop. Europe has been completely stripped of its copper. All cooking utensils, electric equipment, etc., of this metal have long ago been used in the manufacture of materials of war. These must be replaced as soon as possible. Besides, the various nations require large amounts for manufacturing purposes. In 1913, Germany and Austria imported 500,000,000 pounds of copper from this country, while it is estimated that 2,000,000,000 pounds will not meet our own demands this year. But a determined effort will be made to reduce the price materially. Committees have been organized in several European countries to devise ways and means of caring for their needs on an economical basis after the war. These organizations, with government co-operation, are planning to buy their metal at prices favorable to themselves or to restrain buying if prices are not suitable.

* * *

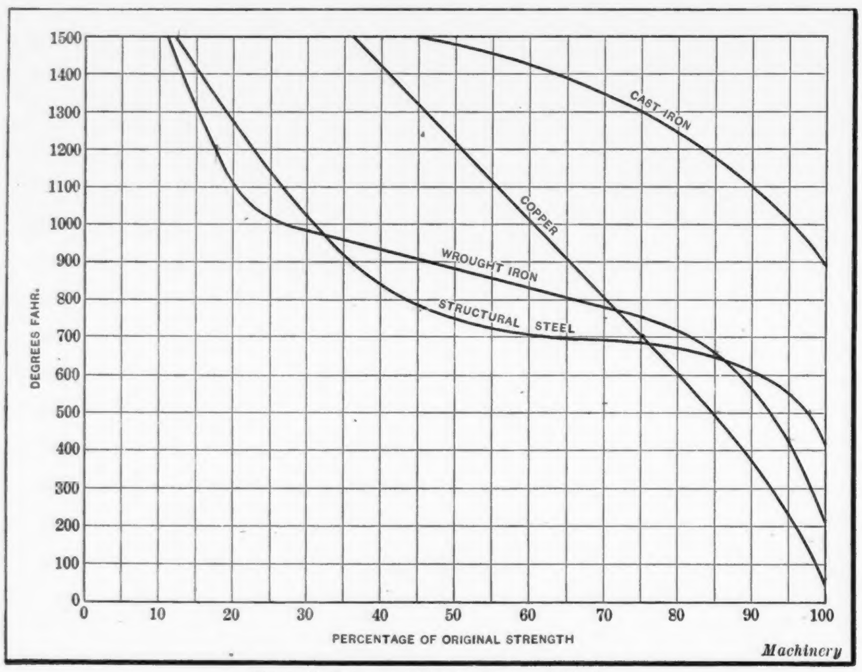
High-class marine oil engines at the present time command a price of from $60 to $65 per horsepower. Figured on a pound basis, they sell at about 40 cents a pound net weight.

## EFFECT OF TEMPERATURE ON STRUCTURAL MATERIALS

BY E. N. PERCY [1]

During the last two or three years, the structural designer has been called upon to design apparatus intended for the extremely difficult combination of pressure and high temperatures. Such designs include retorts, autoclaves, and distillation apparatus. As a matter of fact, power machinery is nowadays so standardized that only in manufacturing apparatus does the designer find a field for trained creative work. The variations in the strength of materials due to change of temperature have been fairly well investigated and made available for the engineer, but as most pressure work has been done at low temperatures the designer has not found it necessary to consult these authorities. With the advent of superheated steam at high pressures and the treating of chemicals under pressure and high temperatures, as in the dye industry or the manufacture of condensation products for electrical purposes, it is sometimes necessary to work under such conditions that the factor of safety ordinarily used is necessarily lowered.

The accompanying diagram shows the curves of strength for different materials under varying temperatures. The data for these curves have been averaged from experiments made by various authorities in different parts of the world. It will be noted that cast iron withstands heat the best; the strength has a tendency to increase up to 900 degrees F., after which it decreases at a fairly uniform rate until its melting point is reached. The use of cast iron for the heat chambers of hot-bulb engines operating at a bright orange heat, that is, in the neighborhood of 1800 degrees F., is well known. These engines usually operate at a maximum compression pressure of about 60 pounds and several checks by the writer indicate that the factor of safety averages 3 to 4 and in some cases is as low as 2.




Strength Curves of Copper, Iron and Steel

The strength of structural steel increases slightly up to 400 degrees F., and then decreases rapidly until 800 degrees is reached, where it has about 40 per cent of its original strength. From this point on the decrease is fairly uniform until its melting point, in the neighborhood of 2000 degrees F., is reached. Wrought iron weakens at lower temperatures than structural steel. It follows the same general laws, but shows a somewhat greater strength throughout after rising above 650 degrees F. The strength of copper decreases from the beginning, at a uniform rate, until its melting point is reached.

These data are modified by surrounding conditions in each particular design. For instance, with cast-iron retorts it is practically impossible to get a tight casting in the average foundry, and the making of cast-iron retorts, gas benches, and autoclaves for high-temperature work is now monopolized by a few foundries who make a specialty of this type of casting. As a rule, some material is added to the iron to make it more fluid so that it will mold in a more homogeneous form. Wrought iron and steel tend to oxidize rapidly under high heats. This tendency is combatted, to some extent, by the various processes of covering with protective, non-oxidizable substances, such as aluminum, porcelain or lead. Copper oxidizes badly at high temperatures and can only be used for special types of high-temperature work. Alloys of copper with tin or zinc are particularly objectionable because the tin and zinc tend to separate, leaving a porous copper that rapidly breaks down. Every practical man knows that brass "rots" when heated. Tobin bronze and similar compounds of copper will withstand fairly high temperature without deterioration, and may be forged or subjected to other heat processes.

The industrial world at present is in need of a thorough and detailed investigation of the strength of various structural materials at high temperatures, also of methods of protecting structural materials from chemical attack. At the present time it is not possible to realize certain valuable laboratory processes because apparatus to withstand the chemicals cannot be manufactured on a large scale.

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## USES OF SLIDE-RULE

BY E. J. GIBSON [1]

When making calculations on the slide-rule, it is often convenient to be able to set the runner accurately to a mixed number containing a common fraction. The prevailing practice is to refer to a table of decimal equivalents and set the runner as nearly correct as can be determined by the eye. This finding of the decimal equivalents can be eliminated in many cases and the runner set accurately by a simple rule that requires but a short mental calculation.

Multiply the integral by the denominator of the fraction and set the slide so that the product on the C scale is over the integral on the D scale. It will now be found that the graduations on the C scale divide the preceding integral space on the D scale into as many parts as the denominator of the fraction. Commencing at the integral, pass the runner over as many of the divisions as there are in the numerator of the fraction, and the runner is accurately set.

*Example*—Set the runner to 5 13/32. As $5 \times 32 = 160$, set 160 on the C scale over 5 on the D scale. Note that 192 on the C scale is over 6 on the D scale, thus dividing the space between 5 and 6 on the D scale into thirty-two parts. Commencing at the figure 5, move the runner over 13 of these divisions and it is set accurately to 5 13/32.

Sometimes it is desired to convert the final result of a calculation into a mixed number. This can be done by simply reversing the process.

*Example*—What is 2.89 expressed in the nearest sixty-fourths? As $2 \times 64 = 128$, set 128 on the C scale over 2 on the D scale and it will be found that $2.89 = 2\ 57/64$, very nearly.

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* * *

Times have changed since Ruskin wrote: "He who works with his hands only is a mechanic; he who works with hand and head is an artisan; and he who works with hands, head and heart is an artist," but the central thought is as true today as when it was written. The operator who runs a machine without thought is a mechanic in the degraded sense of the word—he is virtually a part of the machine, and will so remain until he learns to use his head.

# Lubrication of Cutting Tools—3

by Edward K. Hammond[1]

IT has been the experience of manufacturers using large numbers of screw machines and other machine tools on which a lot of cutting oil is required that the operators of these machines are likely to be troubled from sores on their hands and arms. This trouble has become serious in some shops where cases of infection of small cuts and scratches have resulted in employes losing considerable time and, in some cases, in the amputation of hands or arms. The introduction of employers' liability laws has stimulated investigation of this subject, and it is now believed that these cases of infection are due to the presence of disease-producing bacteria in the oil; to overcome trouble from this source various methods of sterilization have been developed. Chief among these are sterilization by heat and by introducing a germicide into the oil or cutting compound. There is a wide diversity of opinion in regard to the development of bacteria in oils or cutting compounds and the possibility of securing valuable results by sterilization. This fact is indicated by the contradictory results obtained by different investigators, to which reference will be made.

### Sterilization by Heat

When the oil or cutting compound is sterilized by heat, the practice is to have a smaller tank connected with the storage tank into which the oil can be pumped. This tank is usually provided with a coil through which steam may be passed to heat the oil, and after this has been done the steam is shut off and cold water passed through the oil to reduce its temperature to that at which it should be returned to the work to give the best results. The following is a report of tests conducted on mineralized lard oil, which show, first, that it is possible to develop bacteria in oil, and, second, that sterilization at a temperature of 140 degrees F. is an effective means of removing such bacteria.

We divided the oil into four portions that were passed through the process of filtration which we use. After being filtered, these four portions were treated as shown in Table I. The counts were made after incubation of forty-eight hours at 37 degrees C. There was no growth in the portion heated at 140 degrees F. after incubation for forty-eight hours at 37 degrees C. Another portion of the oil was heated at 140 degrees F. for twenty minutes and incubated for twenty-four, forty-eight, seventy-two, ninety-six, and one hundred twenty hours. At every twenty-four hours of incubation, the oil was examined for growth, and at the expiration of one hundred twenty hours no growth appeared. You will note that the original dirty oil showed a bacteria count of 24 per cubic centimeter and that the three samples that were heated for twenty minutes at a temperature of 80, 100, and 120 degrees F. were not properly treated to kill all bacteria, but that treating the oil at 140 degrees F. seemed to free the oil from bacteria.

In order to check up this last treatment, samples of the oil that had been treated at 140 degrees F. were set aside and allowed to incubate for twenty-four, forty-eight, seventy-two, ninety-six, and one hundred twenty hours. These samples, which were examined after every twenty-four hours, showed no trace of bacteria, and it is safe to assume that if after one hundred twenty hours no growth appeared, all the bacteria had been killed. Our chemist claims that the heat-treatment at 140 degrees F. for twenty minutes is enough to kill all the most common bacteria, such as the streptococci and other bacteria which cause infection of flesh wounds, as well as tuberculosis bacteria.

The results of the preceding test seem to show conclusively that bacteria can develop in mineralized lard oil and also that sterilization by subjecting the oil to a temperature of 140 degrees F. is the means of killing these bacteria. In conducting any form of scientific research, it is never safe to place reliance upon results obtained in individual cases; in

**TABLE I. RESULTS OF STERILIZATION TEST**

| Time Heated, Minutes | Temperature, Degrees F. | Bacteria per Cubic Centimeter[1] |
|---|---|---|
| 20 | 80 | 22 |
| 20 | 100 | 15 |
| 20 | 120 | 7 |
| 20 | 140 | 0 |

*Machinery*

[1] Note: The oil before treatment contained 24 bacteria per cubic centimeter.

[1] Associate Editor of MACHINERY.

order to draw general conclusions information must be obtained from a great variety of sources. It is entirely possible that while this method of sterilization would prove effective for some oils, it would be totally inadequate for other oil mixtures and cutting compounds. It is also possible that elimination of bacteria might be due to a change in composition of the oil after being used and not to the sterilization process to which it was subjected.

That such a possibility exists is emphasized by the result of research work recently conducted in a prominent laboratory with the view of furnishing a well-known manufacturing firm with exact information as to the causes of infection of cuts on the hands and arms of men operating machines where a large quantity of oil or cutting compound is used. These investigations have not yet been brought to a definite conclusion, but they have progressed far enough for the investigators to be able to state that after being placed in use any oil mixture containing petroleum undergoes a change in composition which results in producing a powerful germicide in the oil, thus rendering it absolutely sterile. It is the view of investigators in this laboratory that many cases of infection of cuts that are attributed to bacteria carried by oil are actually caused by bacteria that find their way into abrasions of the skin from dirty towels and an infinite number of other sources. It has been suggested that if such a change in composition results in making an oil absolutely sterile, the development of bad sores on the hands of machine operators may be due to any of the following causes: (1) The oil may have a slight soluble action on brass parts of the machine or brass products and thus form a verdigris which causes infection of cuts. (2) Certain aldehydes or other products are formed in the oil, and these cause trouble when they get into cuts or other abrasions of the skin. (3) The presence of free fatty acids in the oil causes trouble in the same way. In the two latter cases it is also assumed that these aldehydes or acids find their way into the stomach and cause nausea, lack of appetite, and other indispositions from which some industrial workers suffer who operate machines on which a lot of oil or cutting compound is used. That such contradictory opinions as those just cited are expressed today shows that the subject of oil sterilization is still in what may be called an experimental stage. The subject is one of great importance, and it is to be hoped that definite conclusions will soon be reached that will enable oil to be treated in a way that insures workmen against danger from bacteria, if this really constitutes a source of infection.

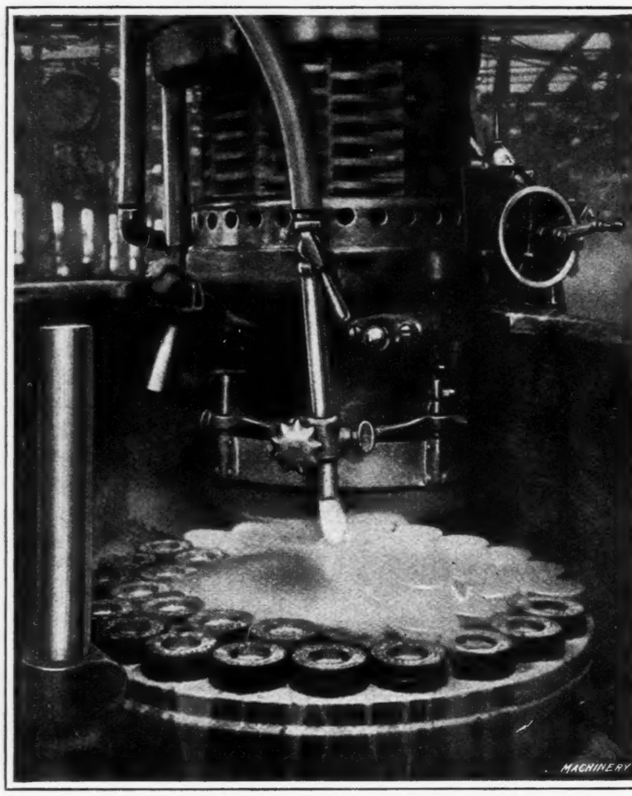

Fig. 60. Delivering Coolant to Wheel on Blanchard Surface Grinder

Oil mixtures containing cottonseed oil and other vegetable oils become rancid after being in use for some time, and this is due to the development of certain molds and bacterial growths. Investigations conducted up to the present, however, tend to show that these are not of disease-producing types and so should not be the cause of infection.

### Sterilization by the Addition of Germicide

The sterilization of cutting oils and compounds is still in the process of development, and some manufacturers are now experimenting with the use of carbolic acid, formaldehyde, creosote oil, and other germicides. Small quantities of such chemicals are added to the oil, and a little thought will make it evident that such additions have an important advantage over sterilization by heat in that they are circulated through the pump, pipe line, machines, and back to the storage tank, thus having an opportunity of keeping the entire system in a sterile condition. In one well-known manufacturing plant it is the practice to add one ounce of creosote oil to each twenty-five gallons of cutting compound used in the factory. Similarly, a well-known firm of oil refiners recommends the addition of 2 per cent of carbolic acid to oils or cutting compounds. Carbolic is a weak acid, so far as its action on metals is concerned, and this addition would not result in damaging the machine bearings or the finished work; this acid is also one of the strongest germicides known to science, and such an addition ought to prove helpful in freeing oils and cutting compounds from bacteria.

Fig. 61 shows, in diagrammatical form, the arrangement of a complete Richardson-Phenix oil filter and sterilizer. Dirty oil from the machines enters the system through pipe *A* and passes through the series of chip baskets, baffle plates, magnetic separators, and cloth filters described in the February number. It then passes to pump *B*, which delivers the clean oil to the machines in the factory. It will be seen that the main pipe line is provided with a pressure relief valve at *C*, so that the pressure at which oil is delivered to the tools will not exceed that which has been found most effective. This is an important point, because experience has shown that in order to work at maximum efficiency either an

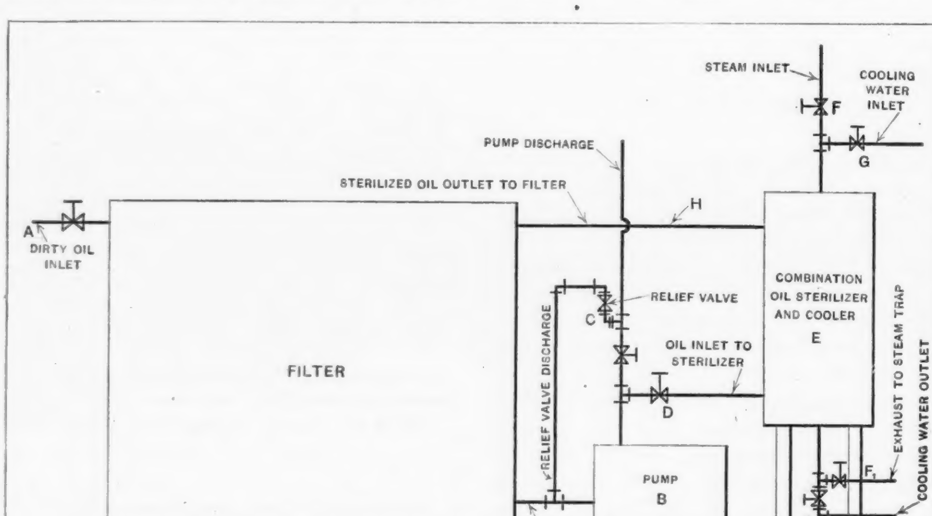

Fig. 61. Diagram showing Arrangement of Filter, Pump and Sterilizer as applied in Central Station Practice of Richardson-Phenix Co.

oil or cutting compound should be delivered at exactly the pressure that will enable it to remain in contact with the work instead of having a tendency to rebound. The fluid which escapes through pressure relief valve *C* is returned through a by-pass pipe to the suction chamber of the pump.

Sterilization of oil at a temperature of 140 degrees F. is recommended once every ten days, and when this treatment is necessary, all the oil in the piping and machine pans is allowed to drain down into the filter tank and sterilizer. Oil is pumped through valve *D* into sterilizer *E*, which, it will be seen, is connected with a double pipe line at both top and bottom to provide for passing either steam or cold water through the coil in the sterilizer. After having passed through the sterilizer the oil is carried through a by-pass pipe that carries it back to the filter tank and thence through the filter units back to the sterilizer. This circulation of oil is continued until all the oil in the system has reached a temperature of 140 degrees F.; the oil is kept at this temperature for twenty minutes. Incidentally, repeated passing of the oil through the filter also gives it a thorough cleaning. While the oil is being heated, valves *F* and $F_1$ are opened to permit steam to pass through the coil in the sterilizer, and after this has been done, these valves are closed and valves *G* and $G_1$ are opened to allow cold water to flow through the coil, thus cooling the oil for subsequent use. Circulation of the oil through the filter and sterilizer is continued while it is being cooled.

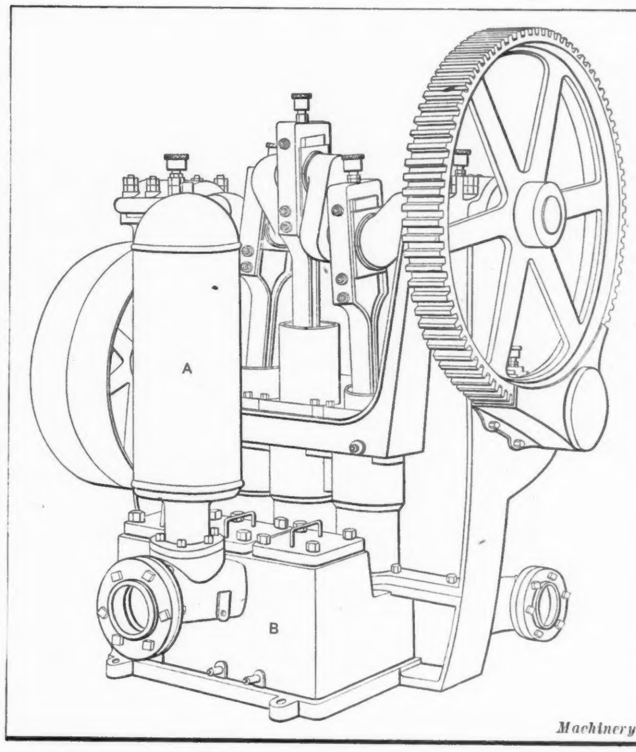

Fig. 62. Single-action Triplex Plunger Pump made by Goulds Mfg. Co.

The systems of filtering and distributing oil described can be highly endorsed, but whether the system of sterilization is effective is a question. In order to sterilize effectively there are two points that must receive careful attention, *i. e.*, all the bacteria must be killed, after which the sterilized oil must be placed in a container which has also been sterilized in order to keep it free from germs. Even though the temperature of 140 degrees is high enough to insure the killing of all bacteria in the oil, it is doubtful whether this would be permanently effective, owing to the fact that the sterilized oil is circulated through pipe lines and machine pans that have not been sterilized. Those who are familiar with the growth of bacteria know that they develop at a rapid rate, and so, even if all bacteria are killed in the oil treated in the sterilizer, the return of this oil to the unsterilized pipe line system would give an opportunity for the development of bacteria long before the lapse of the ten-day period. Many bacteriologists would also be inclined to question the efficacy of sterilization at 140 degrees F., as it is generally conceded that a much higher temperature is required to insure thorough sterilization. A lower temperature may be sufficient to kill existing bacteria, but the spores from which bacteria develop, which correspond to seeds of plants, have greater vitality than the fully developed bacteria, and it only requires a few hours for these to develop into bacteria.

### Pumps Used in Central Station Practice

Pumps used for distributing oils and cutting compounds from central stations are usually of either the plunger or centrifugal type, and each of these has points in its favor. The following gives a brief description of the reciprocating or plunger type of pump and of the centrifugal pump.

### Reciprocating or Plunger Type of Pump

Fig. 62 illustrates a single-acting triplex plunger pump built by the Goulds Mfg. Co. These pumps are ordinarily driven by individual electric motors, as shown in Fig. 63, which also illustrates the Richardson-Phenix filter used for purifying lard oil in the factory of the Marlin Arms Corporation, New Haven, Conn. The pumps are geared down so that the pump speeds vary from about 40 to 60 revolutions per minute. When delivery of a large volume of lubricant is required, pumps with three plungers are used in order to secure uniformity in pressure and rate of delivery, the results obtained in this way being shown diagrammatically in Fig. 64. In Fig. 62, *A* is an air chamber against which the pressure is developed, the air acting as a cushion to absorb shock and help to maintain the pressure at a uni-

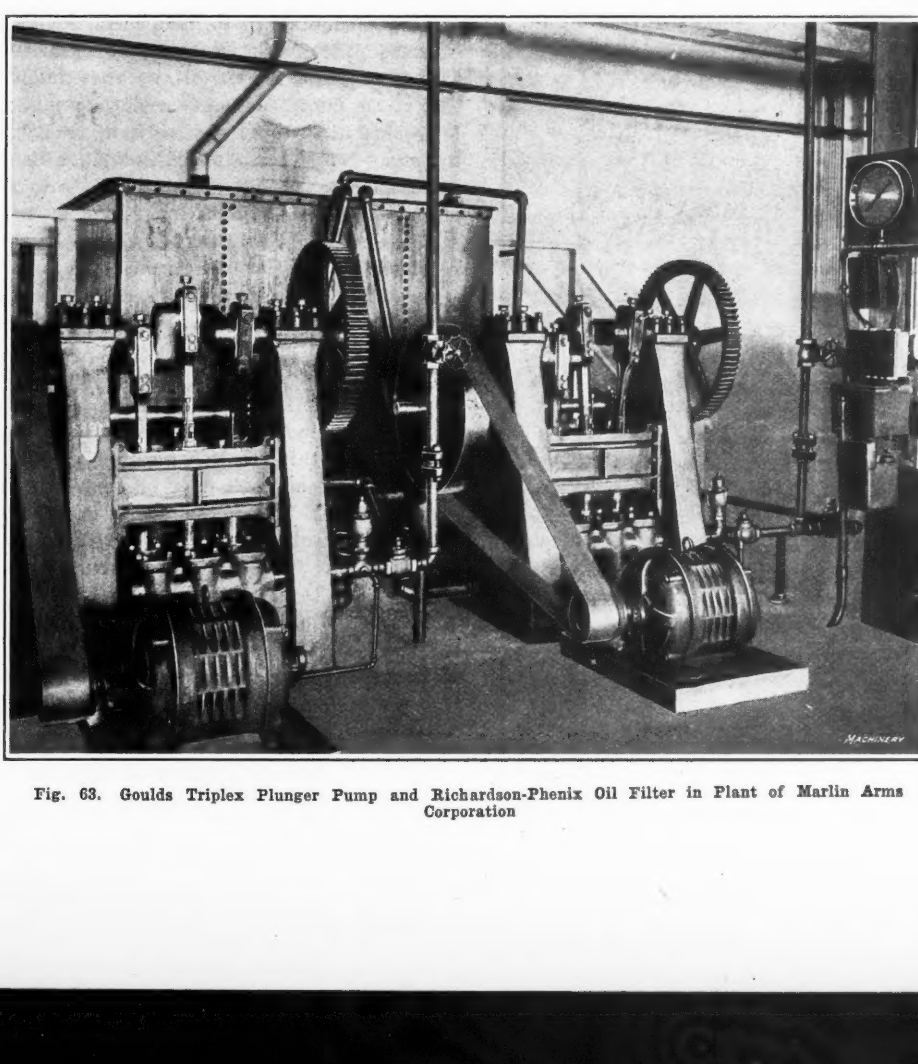

Fig. 63. Goulds Triplex Plunger Pump and Richardson-Phenix Oil Filter in Plant of Marlin Arms Corporation

form level. In case *B* are contained inlet and discharge valves for each of the cylinders. Pumps of this type are made in sizes ranging from 8¼ by 10 inches down to 4 by 4 inches, with capacities from 30 to 400 gallons per minute. Any desired pressure may be maintained by means of a by-pass and pressure regulating valves that can be set to give the required pressure. Table II gives capacities of plunger pumps for various cylinder diameters and lengths of stroke.

### Centrifugal Pumps

The operation of centrifugal pumps is based upon the action of centrifugal force. Pumps of this type are usually run direct-connected to an electric motor, as shown in Fig. 65, and oil or other fluid comes to the pump through a suction pipe. In starting the pump it is usually necessary to prime it, or in other words, to fill the suction pipe and pump casing with fluid. The impeller consists of a wheel with passages formed in it in such a way that the fluid enters from the suction pipe at points near the center of the impeller and is expelled from the periphery into the volute chamber. This volute chamber connects the pump with the delivery pipe. Various arrangements are used for priming pumps, one of the most convenient of which is to use a foot-valve in the suction pipe and have a pipe connection with the delivery pipe so that by opening a valve the suction pipe and pump casing may be filled. In other cases hand pumps are used to raise the fluid in order to fill the suction pipe and pump casing.

Centrifugal pumps have one important advantage where lubricant is delivered to all machines from a central distributing station in that they may be designed to deliver lubricant at a specified pressure at the tools, and when this pressure is reached the pump will continue to "churn" without increasing the pressure. Large centrifugal pumps are usually built according to specifications of the purchaser and are arranged to develop a given pressure. Where pumps of this kind deliver lubricant to tools on several floors and it is required to have the same pressure on all floors, the usual method of procedure is to design the pump to deliver the required pressure on the top floor; on lower floors where there is less loss of pressure due to a smaller static head and friction loss in the line, gate valves can be used to throttle down the pressure so

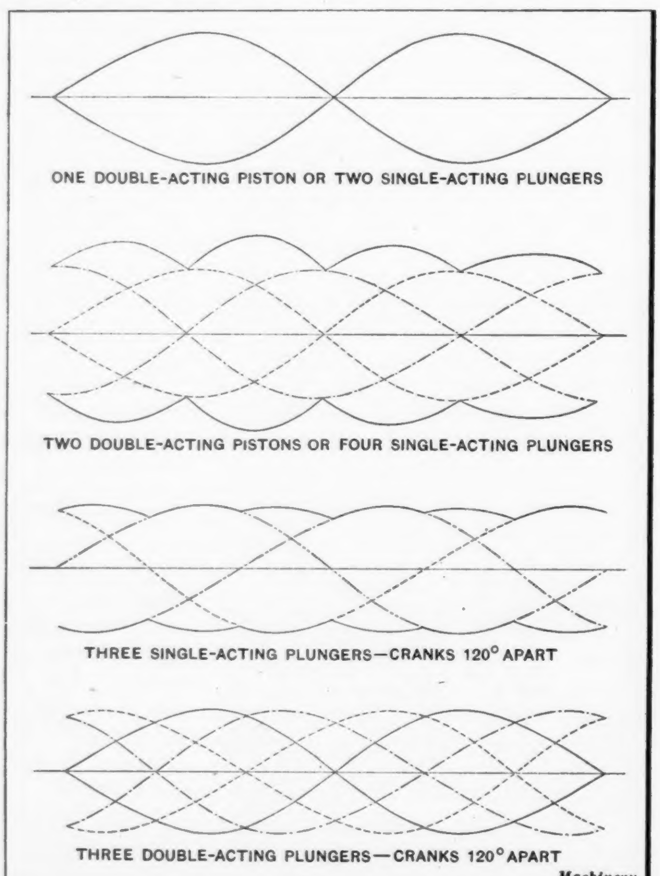


**Fig. 64. Diagram illustrating how Plungers of Multiple-plunger Pump tend to neutralize Variations of Pressure in Different Cylinders**

TABLE II. CAPACITIES OF RECIPROCATING PUMPS [1]

| Diam. of Cyl., In. | Area, Square Inches | Length of Stroke in Inches — Capacity per Stroke in Gallons or Decimal Parts Thereof | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| ½ | 0.196 | 0.002 | 0.003 | 0.003 | 0.004 | 0.005 | 0.006 | 0.007 |
| ⅝ | 0.307 | 0.003 | 0.004 | 0.005 | 0.007 | 0.008 | 0.009 | 0.011 |
| ¾ | 0.442 | 0.004 | 0.006 | 0.008 | 0.010 | 0.011 | 0.013 | 0.015 |
| ⅞ | 0.601 | 0.005 | 0.008 | 0.010 | 0.013 | 0.016 | 0.018 | 0.021 |
| 1 | 0.785 | 0.007 | 0.010 | 0.014 | 0.017 | 0.020 | 0.024 | 0.027 |
| 1⅛ | 0.994 | 0.009 | 0.013 | 0.017 | 0.022 | 0.026 | 0.030 | 0.034 |
| 1¼ | 1.227 | 0.011 | 0.016 | 0.021 | 0.027 | 0.032 | 0.037 | 0.043 |
| 1⅜ | 1.485 | 0.013 | 0.019 | 0.026 | 0.032 | 0.039 | 0.044 | 0.051 |
| 1½ | 1.767 | 0.015 | 0.023 | 0.031 | 0.038 | 0.046 | 0.054 | 0.061 |
| 1¾ | 2.405 | 0.021 | 0.031 | 0.042 | 0.052 | 0.063 | 0.073 | 0.083 |
| 2 | 3.142 | 0.027 | 0.041 | 0.054 | 0.068 | 0.082 | 0.095 | 0.109 |
| 2¼ | 3.976 | 0.034 | 0.052 | 0.069 | 0.086 | 0.103 | 0.121 | 0.138 |
| 2½ | 4.909 | 0.043 | 0.064 | 0.085 | 0.106 | 0.128 | 0.149 | 0.170 |
| 2¾ | 5.940 | 0.051 | 0.077 | 0.103 | 0.129 | 0.154 | 0.180 | 0.206 |
| 3 | 7.069 | 0.061 | 0.092 | 0.122 | 0.153 | 0.184 | 0.214 | 0.245 |
| 3¼ | 8.296 | 0.072 | 0.108 | 0.144 | 0.179 | 0.215 | 0.251 | 0.287 |
| 3½ | 9.621 | 0.083 | 0.125 | 0.167 | 0.208 | 0.249 | 0.292 | 0.333 |
| 3¾ | 11.045 | 0.095 | 0.143 | 0.191 | 0.239 | 0.287 | 0.335 | 0.382 |
| 4 | 12.566 | 0.109 | 0.163 | 0.218 | 0.272 | 0.326 | 0.381 | 0.435 |
| 4¼ | 14.186 | 0.123 | 0.184 | 0.246 | 0.307 | 0.368 | 0.429 | 0.491 |
| 4½ | 15.904 | 0.138 | 0.207 | 0.275 | 0.344 | 0.413 | 0.482 | 0.551 |
| 4¾ | 17.721 | 0.153 | 0.230 | 0.307 | 0.384 | 0.460 | 0.537 | 0.614 |
| 5 | 19.635 | 0.170 | 0.255 | 0.340 | 0.425 | 0.510 | 0.595 | 0.680 |
| 5¼ | 21.648 | 0.187 | 0.281 | 0.375 | 0.469 | 0.562 | 0.656 | 0.750 |
| 5½ | 23.758 | 0.206 | 0.309 | 0.411 | 0.514 | 0.617 | 0.720 | 0.823 |
| 5¾ | 25.967 | 0.225 | 0.337 | 0.449 | 0.562 | 0.674 | 0.787 | 0.899 |
| 6 | 28.274 | 0.245 | 0.367 | 0.489 | 0.612 | 0.734 | 0.857 | 0.979 |

*Machinery*

[1] Note: Figures are for one single-acting cylinder. For single-acting triplex pumps multiply by 3. For single-acting duplex pumps multiply by 2, etc.

that it will be the same as on the top floor. The same practice is used with other types of pumps; but in the case of plunger pumps it is necessary to have a pressure-control valve and by-pass, as previously mentioned. In addition to their application for distributing lubricants from a central station, centrifugal pumps are employed on grinding machines and other machinery for pumping cutting compound to the wheel and work.

### Positive Pump Pressure and Gravity Oil Feeds

Two systems are in general use for delivering lubricant from a central station to machines in the shop. One of these consists of pumping the purified lubricant up to a storage tank at the top of the building from which it flows by gravity to the machines on different floors. The other is to pump lubricant direct to the different machines. Each system has its advocates and each seems to have certain points in its favor. The claim is made for the gravity tank system that a uniform pressure is obtained for the oil, without fluctuations due to pulsation of the pump. It is also pointed out that should the pumps fail, there is a supply of oil in the gravity tank that will carry the machines for a limited space. This may be a point of some importance, but the claim made in regard to variations of pressure due to pulsation is not so important, as will be seen by reference to Fig. 64, which shows how each cylinder in a triplex pump, which is one type commonly used for this service, tends to neutralize variations in pressure in the other two cylinders, so that the combined effect is a close approximation of normal pressure.

Regardless of whether a gravity tank or direct-pump delivery is employed, it is necessary to keep the pressure of lubricant delivered to machines on different floors as nearly uniform as possible, and this result is secured by having valves placed in the pipe lines on each floor or supplying individual valves at each machine. For average work, the pressure in the pipe line is usually maintained at from 28 to 30 pounds per square inch. The valves at the machines can be adjusted to throttle down the pressure to exactly the required amount. In cases where a variety of machines on the same floor call for delivery of lubricant at different pressures, it is common practice either to have a number of valves in different branches of the pipe line leading to the different classes of machines or to provide an independent valve on each machine.

### Return of Oil to the Central System

After flowing over the tools and work the lubricant is col-

lected by the usual means provided on machine tools and returned through drain pipes to troughs in the floor. These are covered with boards that may be lifted to give access to the trough, when this is necessary, the arrangement being shown in Fig. 66. The troughs are usually about 6 inches wide by 1 foot deep, the size depending on the amount of lubricant to be handled, and it may be mentioned that troughs are used in place of pipes to prevent the system from becoming clogged by chips or through gumming of oil. In buildings with concrete floors these troughs may be placed in the concrete, but if machines are carried on wooden floors the drain pipes can pass through the floors and discharge into galvanized-iron troughs suspended from the ceiling of the room below. An advantage of having all the oil handled from a central station is that it reduces fire hazard, as no oil is kept in the base of the machine and the small quantity adhering to chips is insufficient to support a fire. The oil storage and filter can be located away from the main building or put in a fireproof compartment.

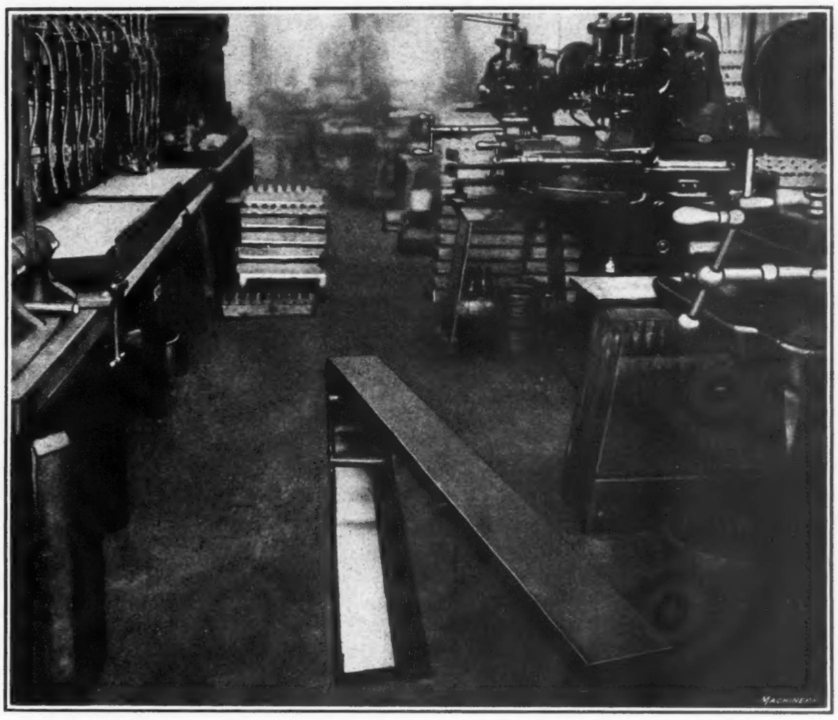

Fig. 66. Cover lifted from Drain Trough in Floor, showing Means of Access in Case Trough becomes clogged

#### Planning a Central Distributing and Purifying Plant

In planning to install a central station for the distribution and purification of oils and cutting compounds, information should be given concerning the number, size, and make of the various machine tools which are to be supplied with lubricant, the average and maximum number of machines that will be operating at one time, the kind of oil or cutting compound used, and the volume of lubricant which it will be desired to circulate per hour. In addition, information should be given concerning the different metals that are to be cut. In many instances it is possible to make use of the existing oil-storage and piping systems and simply add filters and sterilizers to make the system automatic.

Limitations of the central station for delivering oils and cutting compounds are the high first cost of installing such a system and the possibility of trouble arising that would interfere with the delivery of lubricant to the shops, thus causing loss of time and damage to cutting tools. The liability of difficulty from this source is materially reduced by installing one or more reserve pumps. Another criticism of the central distributing station is that a heavy additional expense is involved if provision is made for delivering different kinds of oils and compounds to various classes of machines in the factory. The advantages of the practice of distributing all cutting oils and compounds from a central station are as follows: provision of clean oil, possibility of returning oil to the tools at a low temperature, sterilization of the oil to prevent infection, reduction of fire hazard, longer life for cutting oils and compounds, saving of labor in handling oil, saving of oil wasted in handling, improvement of sanitary conditions in factory, and continual stirring of soluble compounds which insures uniformity of solution.

#### Filters and Trucks for Transporting Oil

In some cases where it is undesirable to install a system of piping for the distribution of oil to all machines from a central station, the oil may be purified by passing it through a system of strainers and filters similar to that illustrated in Fig. 47 in the February number. For this purpose separate straining and filtering outfits may be built with a capacity for handling any desired amount of oil or cutting compound. One of these small units, built for use in filtering kerosene in the factory of the Hess-Bright Mfg. Co., Philadelphia, Pa., is shown in Figs. 67 and 68. When an equipment of this kind is employed trucks are used for conveying oil to machines in the factory and for returning used oil to the filter. Fig. 69 shows an excellent truck for handling work of this kind. It will be seen that it has two compartments, each of which has a capacity for 160 gallons. The truck is taken around through the shop and dirty oil is pumped out of pump reservoirs on machines into the "dirty-oil receiving tank." After this reservoir has been cleaned (if necessary), a fresh supply of oil is pumped in from the "clean-oil tank" in the truck and the dirty oil is then taken back to the filter. A truck of this kind does away with danger of spilling oil on the floor.

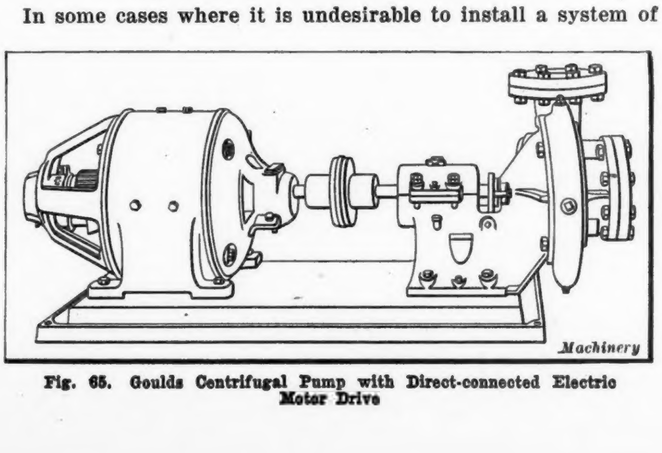


Fig. 65. Goulds Centrifugal Pump with Direct-connected Electric Motor Drive

#### Methods of Conducting Shop Tests

In many shops where facilities are not available for determining the relative value of different oils and cutting compounds, dependence is often placed upon the judgment of the shop superintendent or foremen, and this is likely to prove unsatisfactory from one of two causes. When this practice is followed, the man who determines what oil or cutting compound to use will often base his selection upon ideas formed at the time he learned his trade, and these may be badly out of date. The judgment of such a man is likely to lead him to specify lard oil or a mixture containing a high percentage of lard oil for use on many classes of work where satisfactory results could be obtained with a cheap soluble oil compound. On the other hand, a man who is inclined to economize may carry this to the extreme and specify an oil or cutting compound which may be bought at a low price, but which will prove costly through failure to keep the cutting tools in good condition or through tendency of the oil to gum, turn rancid, etc., making it unfit for use after a short period of service.

#### Testing Oils and Cutting Compounds

In the purchase of oils and cutting compounds, as in the case of all equipment and materials used in machine shops, the points of vital interest to the buyer are first, the quality

of service which he will obtain, and second, the length of time for which the lubricants will continue to render this service. The most obvious way of securing information on these points is to conduct running tests on machines and lubricate the cutting tools with the oil or compound which the purchaser has under consideration. In this way he may obtain information on the following points: (1) The efficiency of the oil or cutting compound as a lubricating or cooling medium, as determined by the length of time that the tools "stand up" between grindings. (2) The amount of service obtained before the supply of oil is exhausted through loss from splashing, being carried away on chips, and similar causes. (3) Ability of the fluid to radiate heat rapidly, as determined by noting the uniformity of temperature indicated by a thermometer suspended in the reservoir. (4) Freedom from acids or alkalies, as indicated by lack of tarnish produced on a polished metal disk immersed in the fluid for several hours. (5) Cost per running hour. First cost only becomes a matter of importance after the user has satisfied himself that the lubricant is capable of giving satisfactory service on his work. The following describes current practice in conducting shop tests on oils and cutting compounds.

### Method of Conducting Shop Tests

In conducting shop tests the aim should be to operate the machine and cutting tool as nearly as possible under conditions that will exist in actual manufacturing. The best plan is to select a piece of work on which the tool can be run for at least one week, and before starting work, care should be taken to see that the machine is properly lubricated and that the reservoir, pump and piping are thoroughly cleaned to remove all the lubricant previously used. Attention should also be paid to the cleaning and lubricating of all bearing surfaces and slides before the machine is loaded for test. If the oil or cutting compound is to be given every opportunity of producing satisfactory results, it is not sufficient to allow it to simply flow onto the top or side of the tool; the feed pipe should be arranged in such a way that a copious stream will be carried to the tool point and the surface of the work being machined in order that both tool and work may be properly lubricated and cooled. Care in grinding the cutting tools is of equal importance because the test must be conducted under conditions equal to the best that can be expected in actual manufacturing operations. Improper grinding of the tool not only results in the generation of more heat, but also in rapid destruction of the cutting edge; and failure to provide means for the delivery of the required volume of lubricant is an obvious injustice to the manufacturer of the lubricant who is endeavoring to show what his product is capable of doing. Many good cutting compounds have been condemned through failure to provide a proper arrangement of feed pipes and to have the tool properly ground.

When the machine reservoir has been properly filled with oil or cutting compound care should be taken to see that this lubricant remains uniform throughout the test; this is particularly important in the case of emulsions made from soluble oils and water. Attention to this point will be of assistance in figuring the running cost per hour or the cost of lubricant for producing a given quantity of work. In a test of this kind with different oils and cutting compounds the following data should be taken: (1) Total running time; (2) time spent in grinding tools; (3) time consumed by delays and in making repairs; (4) condition of tool at start; (5) deterioration of tool; (6) speed and feed employed; (7) number of pieces of work produced; (8) number of gallons of lubricant in reservoir at start; (9) number of gallons of lubricant in reservoir at finish of test. In this connection it may be mentioned that oil ought to be reclaimed from the chips produced and this amount measured and deducted from the quantity of lubricant put in the machine reservoir to start the test. These data will enable an intelligent comparison to be made of oils and cutting compounds from which the purchaser can select those best suited to his requirements.

### Simple Methods of Testing Quality of Oils

Scientific testing of oils and cutting compounds calls for the use of somewhat elaborate apparatus and in order to secure accurate results the man making such tests must have received training as a chemist. Where data are required on the properties of a given oil or compound and the plant has not the facilities of a chemical laboratory, it will be desirable to send samples to a consulting chemist who will conduct an investigation for a moderate fee. At the same time it is desirable for shop men to be able to make a few elementary tests on oil which will give information concerning its probable value for the service required.

*Acidity*—A simple method of determining whether or not an oil or cutting compound contains free acid consists in suspending a piece of polished sheet copper in the oil for a period of two weeks. The presence of acid is indicated by corrosion of the polished metal surface, making it somewhat dull in the presence of even slight traces of acid. If the oil is pure the copper will be bright after being removed from the oil.

*Mineral Oil*—A good test to ascertain whether mineral oil is pure and has been carefully refined consists of dropping a small quantity of strong sulphuric acid into the oil; this will have no effect on the color if the oil is pure, but if fatty material is present the oil will become discolored.

*Animal and Vegetable Oils*—Mineral oil and rosin oil are sometimes used as adulterants for expensive animal and vegetable oils. Mineral and rosin oils differ from other oils in many respects, especially in their appearance when examined by reflected light. Mineral oils show a greenish tinge or "bloom" when examined by reflected light, but when seen by transmitted light, this bloom disappears and the true color of the oil is seen. Rosin oil has the same characteristic except that the bloom is blue. This bloom is due to the familiar phenomenon known as "luminescence," *i. e.*, the property of becoming luminous when exposed to the sunlight. To test animal or vegetable oils for the presence of mineral or rosin oil, place a sample of the oil in a four-ounce bottle and view it by reflected light; the presence of any bloom indicates these impurities. By suitable treatment in the process of refining, oils can be "de-bloomed" so that the characteristic luminescent appearance is not seen when viewed by ordinary reflected light; but when such oils are viewed by reflected light from an ordinary enclosed arc light, the char-

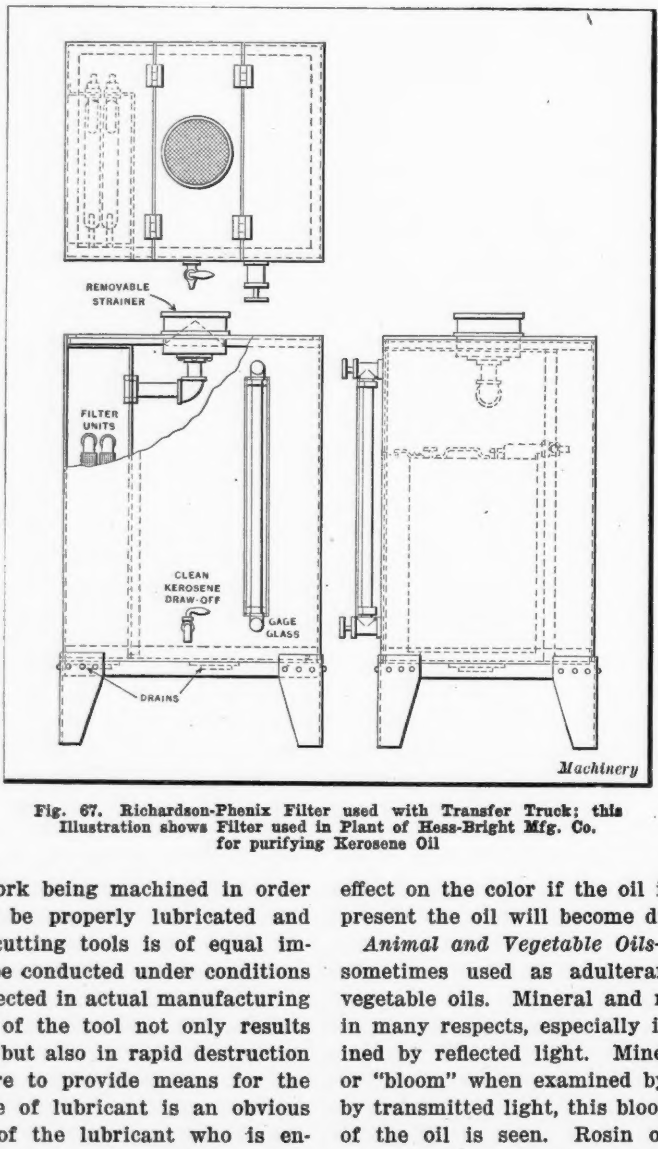


Fig. 67. Richardson-Phenix Filter used with Transfer Truck; this Illustration shows Filter used in Plant of Hess-Bright Mfg. Co. for purifying Kerosene Oil

acteristic appearance will be noted. This test will reveal the presence of minute traces of mineral or rosin oil. Attention is called to the fact that many so-called "mineral lard oils" are sold which consist of mixtures of lard oil and petroleum, and these will naturally show the presence of mineral oil when subjected to this test, but the purchaser who is paying for pure lard oil or other pure oils of animal or vegetable origin, does not want to pay a high price for a product that has been adulterated with cheaper oils.

*Turpentine*—The most common adulterants found in turpentine are mineral oils although wood turpentine and rosin spirits are sometimes added. A simple test for purity of this material is to drop it onto a piece of white paper which is allowed to stand in the air until the turpentine is evaporated. The presence of other oils is indicated by a stain left on the paper; if the turpentine is pure, no discoloration will appear after it has evaporated.

*Lard Oil*—Lard oil is sometimes adulterated with cottonseed oil, and the presence of over 10 per cent of this adulterant may be detected by adding a solution of silver nitrate which will cause it to darken considerably through the formation of metallic silver. This is a simple test performed by merely adding the oil to a test tube containing an equal volume of alcoholic solution of silver nitrate and heating the mixture in a gas flame. The silver-nitrate solution is made by dissolving 1 part of silver nitrate in 200 parts of 95 per cent alcohol and 40 parts of ether.

### Testing Fluidity of Oils

Oils and cutting compounds are consumed through various causes, among which may be mentioned carrying away by chips; loss by oxidation, gumming or turning rancid; leakage from trucks or other forms of conveyors; and spattering from machines. The first two causes of loss are due to inherent properties of the oil and must be guarded against by tests; losses from the latter causes can only be prevented by the exercise of care and the provision of proper means for handling lubricants and preventing them from being thrown from the machines.

When oils have constituents that are easily oxidized or likely to gum, it not only results in loss of oil but also in trouble through clogging pipes, which retards the action of slides and other machine members, and prevents the oil from flowing freely to the point of the tool and work. Oxidation results in the formation of a black sludge in the oil and also in the formation of a tenacious skin or gum, trouble from these sources being particularly marked in the case of some vegetable oils and lard oil of poor quality. In addition, oxidation and gumming reduce the fluidity of the oil and cause an excessive amount of oil to be carried away with the chips. The same is true of oils having too high a viscosity, and with such oils it may be found good practice to add

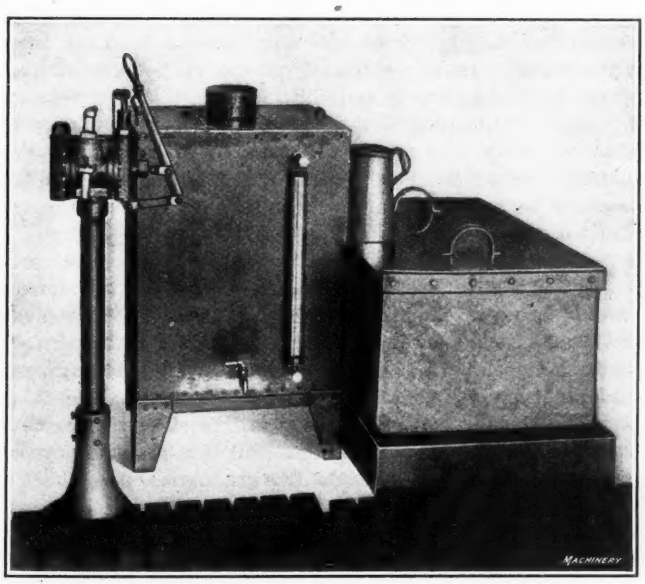


Fig. 68. View of Kerosene Oil Filter shown in Fig. 67, set up in Hess-Bright Factory

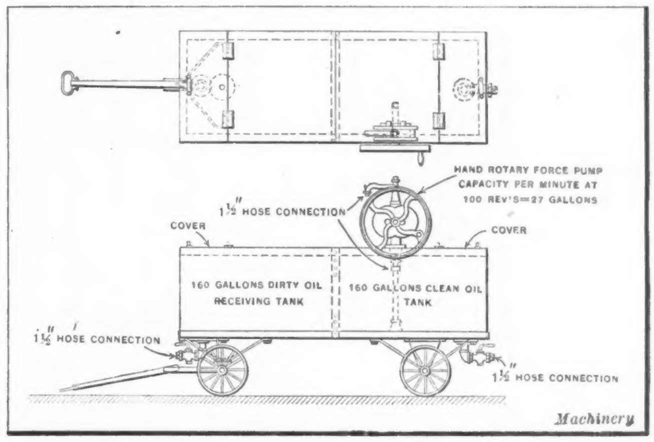


Fig. 69. Truck used for removing Dirty Oil from Machines and substituting Supply of Clean Oil

kerosene oil or some other "thinner" to make them run more freely.

Fig. 70 illustrates a practical test to determine the probable loss of oil through retention by chips. A funnel is lined with flannel and two pounds of fine chips is placed in it. Four ounces of oil is then poured through the funnel and allowed to drain into a second measure; after allowing sufficient time for the oil to drain, the amount in the second measure will indicate how much has been retained by the chips. Tests of this kind should be conducted with new oil and also with oil that has been in use under actual working conditions for some time. In some cases it may be found that the new oil runs through in a satisfactory manner, but that after being used for a time the fluidity will have been seriously reduced. This is particularly true of oils that give trouble through gumming or oxidation, and of poor grades of mineral lard oil in which the lard oil has a tendency to become thick and separate from the mixture so that it is easily retained by the chips. Even when great care is taken in the operation of centrifugal chip separators to recover oil from chips the loss will be quite heavy with oils of this kind, and in making the test for fluidity, oils that do not run freely through the funnel should be viewed with suspicion and should not be accepted if the best results are expected.

In plants where oils are tested in the chemical laboratory stress is likely to be laid upon the results obtained by saponifying the oil by boiling it with an alcoholic solution of caustic potash. This is the chemist's name for the process of making soap from animal oil, and in interpreting the results of his investigation he may fall into the error of recommending the oil having the highest saponification value, unless he is a man who has a thorough knowledge of the requirements that must be met to obtain satisfactory results from cutting oils. If so, he will know that a mixed lubricant containing a large amount of animal oil—which gives a high saponification value—does not necessarily give satisfactory results. This is due to several reasons: it may be that the animal oil is of poor grade, so that it tends to oxidize and gum rapidly; it may be too thick to run freely to the tool and work; or it may give trouble through failure to radiate heat rapidly, etc. While laboratory tests are of great importance in determining the properties of lubricants, their results should not always be relied upon until they have been carefully studied and compared with the results obtained with the oils under working conditions.

### Laboratory Tests on Oils and Cutting Compounds

While information obtained by practical shop tests gives information of direct value to the manufacturer who uses cutting oils, there are a number of tests conducted in the laboratory which yield information concerning the chemical and physical properties of the oil that are of value in determining what its probable efficiency will be when used in the shop. The tests most commonly conducted on oils used for lubricating and cooling metal-cutting tools are for determining the following properties: specific gravity, viscosity, flash point, fire point, and cold point.

### Specific Gravity

Specific gravity is defined as the ratio of the weight of a given volume of fluid under test to that of the same volume of water. Water has a specific gravity of 1 and all oils and cutting emulsions have specific gravities less than that of water. The specific gravity of an oil in some instances may serve as an indication of its purity, as different oils have characteristic specific gravities by which they can be recognized. The most accurate determination of specific gravity is made by means of a pycnometer, two types of which are shown at *A* and *B* in Fig. 71. The type shown at *B* is used for obtaining the specific gravity of asphalt and oils of high viscosity; with these materials trouble would be experienced in cleaning the type of pycnometer shown at *A*, which is the one most commonly used for obtaining the specific gravity of such fluids as oils and cutting emulsions. In making a test, the pycnometer is carefully washed and dried, after which its weight is determined on a chemical balance. It is then filled with distilled water, care being taken to have the water fill the capillary tube in the stopper, after which the combined weight of the pycnometer and water is determined to obtain the weight of this volume of water. The pycnometer is then once more dried and filled with oil, after which it is again weighed to obtain the weight of the oil. The specific gravity may then be easily calculated by dividing the weight of the oil by the weight of the water. It is essential that all weighing be done at a standard temperature, which is 15.5 degrees C. (60 degrees F.). If any weighing is done at another temperature the results must be converted to the standard temperature, because the specific gravity varies with changes of temperature.

Determination of specific gravity by means of the pycnometer is a slow process, and for commercial work sufficiently accurate results may be obtained in other ways. At *C* is shown a Westphal balance used for this purpose. The fluid to be tested is placed in the container and the plummet suspended from the right-hand end of the balance beam is immersed in the fluid. It will be seen that the beam is graduated and carries a counter-poise, the position of which is adjusted on the beam so that the balance comes to rest with the point at the left-hand end opposite the point on the frame. The specific gravity of the fluid is then read direct from the graduation on the beam that comes under the counter-poise.

Another rapid method of determining specific gravity, and one which is commonly used, is by means of a Baumé hydrometer, a number of which are shown at *E*. This consists of a plummet which is weighted at the lower end so that it floats vertically in the fluid to be tested; the depth to which the hydrometer is immersed depends upon the specific gravity of the fluid. As the specific gravity is dependent upon temperature, it is necessary to specify the temperature at which the determination is made. For this purpose some of the hydrometers shown are provided with thermometers. In the case of those that do not have thermometers, it is necessary to determine the temperature with a separate thermometer dipped into the fluid, and make the necessary correction, or to avoid this, oil may be tested at the standard temperature of 60 degrees F. Baumé gravity may be converted into specific gravity by using the following formula:

$$\text{Specific gravity} = \frac{140}{130 + \text{Baumé gravity}}$$

For very accurate work, however, the following formula should be used:

$$\text{Specific gravity} = \frac{141.5}{131.5 + \text{Baumé gravity}}$$

Viscosity may be defined as the tangential force per unit area divided by shear per unit of time; this property represents a measure of internal resistance in the fluid and indicates the magnitude of forces tending to retard a rapid flow of the fluid. It will be evident from this that oils used for the lubrication and cooling of cutting tools should not have too high a viscosity because this would prevent their rapid flow to the point where cooling or lubricating action is required. The viscosity of distilled water is taken as the standard against which the viscosity of other fluids is compared; and owing to the change in the fluidity of oils which takes place with variations in temperature it is obviously necessary for the determination of viscosity to be made at standard temperatures in order that comparison may be made with the viscosity of water at the same temperature.

Viscosity is determined by an instrument known as a "viscosimeter," of which there are a number of different forms. The Saybolt universal viscosimeter was recommended by the American Society for Testing Materials and has been adopted as a standard in the United States. In England the Redwood viscosimeter is the standard, and the Engler meter has been adopted as a standard by the Germans. The Saybolt viscosimeter is shown set up in Fig. 72. At *A* is shown the top of a small container into which is poured the oil to be tested, and surrounding this container is a water bath the temperature of which is raised to the degree at which the test is to be made. Temperatures of 70, 100, 130, and 210 degrees F. are standards for the determination of viscosity (70 degrees on the Saybolt viscosimeter is practically obsolete; some oils deposit paraffin at this temperature and interfere with the test); the temperature to use depends on the viscosity of the oil, high temperatures being used for oils of high viscosity and low temperatures for oils of low viscosity. In stating the viscosity of an oil, information must also be given in regard to the temperature at which the test was made. The temperature of the water bath is raised by an electric heating element *B*, which is immersed in the water until its temperature has been raised to the required degree, as indicated by thermometers *C* and *D*. This heating element is then dipped into the bath or removed, as the case may be, to maintain the required temperature.

The oil to be tested is poured into pan *E* and passes from this through strainer *F* into container *A* in the viscosimeter. This container extends through the bottom of the water jacket, and has a small lower opening fitted with a stopper. Beneath this opening is a glass receiver *G*, which contains sixty cubic centimeters when filled to the graduation line at the neck. In conducting a viscosity test, the stopper is removed from the bottom of container *A* and oil is allowed to flow into receiver *G* until it is filled to the graduation line, the time in seconds required to do this being noted by means of a stop watch, and expressed as a number with the temperature, *i. e.*, Saybolt viscosity of 200 at 100 degrees F. When the "specific viscosity" is desired, the same test is conducted with water in place of the oil, and the viscosity of the water

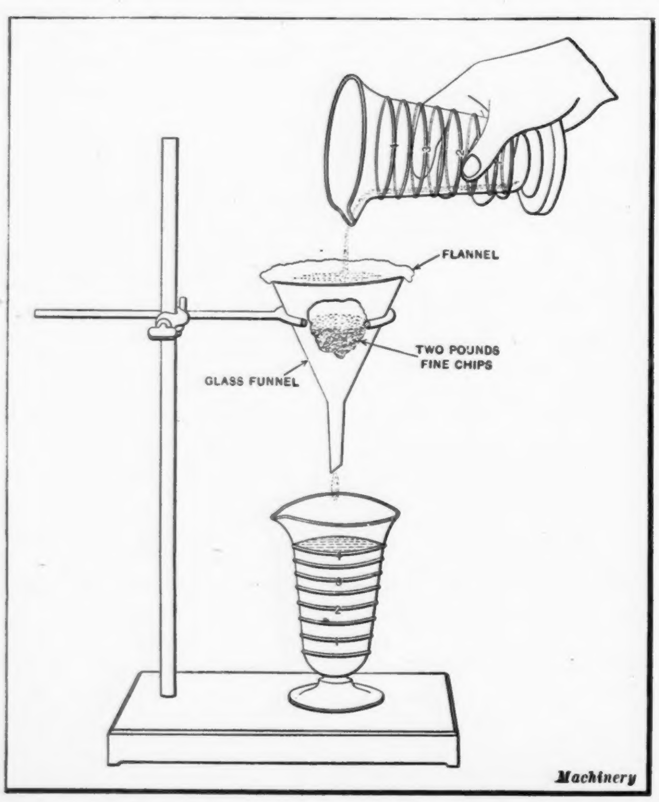


Fig. 70. Simple Method of testing Amount of Oil carried away by Chips

or the time required to run sixty cubic centimeters into receiver $G$ divided into the time required for the same amount of oil gives the "specific viscosity."

$$\text{Specific viscosity} = \frac{\text{Viscosity of oil}}{\text{Viscosity of water}}$$

### Flash Point

The flash point of an oil is the temperature at which sufficient vapor is given off to develop a temporary flash or flame when ignited by a taper or some other convenient means. The use of oils with a low flash point should be avoided, owing to the danger of their starting fires. This is particularly true in the case of automatic screw machines, etc., where kerosene is sometimes used to thin the oil to the required consistency, and where a large volume of oil is exposed in the pan. Determination of the flash point is commonly made in the Cleveland open cup apparatus illustrated in Fig. 73. This consists of a cup $A$ filled with oil, in which is immersed an accurate thermometer $B$ for measuring the temperature. The oil is heated by a Bunsen burner $C$, so the temperature will rise at the rate of ten to twelve degrees per minute, and with each three to five degrees rise in temperature the small gas taper $D$ is applied by passing it horizontally over the surface of the oil. In most laboratories this test is made by applying the taper with each rise of five degrees F., but the American Society for Testing Materials recommends applying the taper after each rise of three degrees F. When the flash point is reached there will be a slight explosion at the surface of the oil, showing that the oil vapor is ignited, and the temperature indicated by thermometer $B$ represents the flash point.

### Fire Point

The fire point of an oil is the temperature at which the oil will continue to burn when a flame is applied to its surface. The determination of this temperature is made in the Cleveland open cup, shown in Fig. 73, used for ascertaining the flash point. The two tests are made together; that is to say, after the flash has been determined the temperature is raised still further with application of the taper at intervals of three to five degrees F., until the point is reached where the oil continues to burn when the lighted taper is applied to its surface. It will be evident that after passing the flash point there will be a momentary ignition of oil vapor each time the taper is applied to the oil, but this must not be confused with the fire point which is not reached until the temperature is sufficiently high to maintain a flame on the surface of the oil when it is ignited. The fire point of oils suitable for lubricating and cooling metal-cutting tools ranges from 30 to 65 degrees F. above the flash point, the average difference being 40 degrees F.

### Cold Point

Oils become more viscous as they cool and finally solidify. Those with too high a cold test should not be used—especially in cold weather—because they are likely to give trouble by failing to run freely to the tools and work and by clogging up supply pipes, etc. In the case of lubricants containing oils refined from crude petroleum, cooling first causes the paraffin particles to solidify which gives the oil a cloudy appearance. The committee on lubricants of the American Society for Testing Materials has applied the terms "cloud test" to the temperature at which this takes place and "pour test" to the temperature at which the oil can just be poured. Both of these come under the general heading "cold test."

Fig. 74 illustrates apparatus for determining these temperatures; it consists of a bottle about 1¼ inch inside diameter and 4 or 5 inches high which is filled with oil to a depth of about 1¼ inch. A special cold-test thermometer is inserted through the cork, having colored alcohol and a long bulb which is immersed in the oil. The bottle of oil is placed in a container filled with cracked ice, and when the temperature of the oil is near the expected cloud-test point the bottle is removed for each two degrees drop in temperature and the oil inspected; when the lower half becomes opaque, the thermometer reading is taken as the cloud-test temperature.

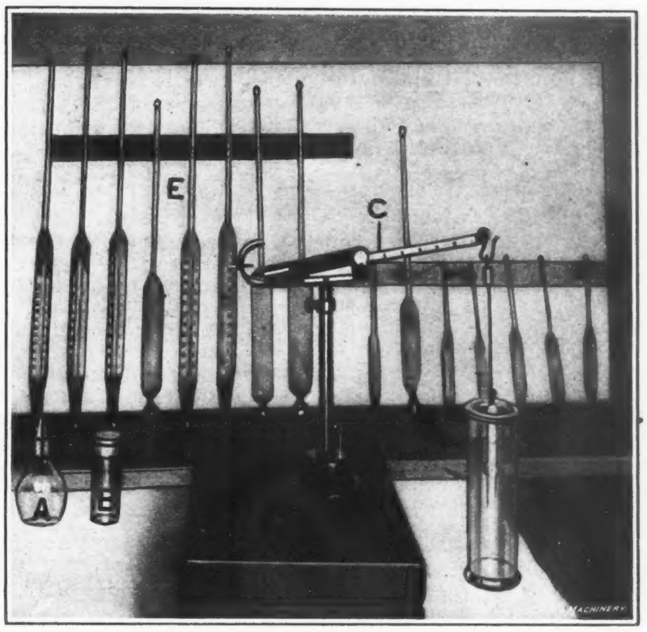

Fig. 71. Pycnometers, Westphal Balance and Baume Hydrometers for determining Specific Gravity of Oils

The pour test is simply a continuation of the cloud test, except that the temperature is noted for each drop of five degrees and the bottle is tilted each time. When the oil becomes solid and will not flow, the previous five-degree point is taken as the cold point of the oil. In making this test care must be taken to tilt the bottle slowly to avoid agitating the oil more than necessary. Where this precaution is not observed, too low a cold point will be found.

### Free Fatty Acids

Free fatty acids represent the amount of free organic acid present in the oil, and this should not be confused with mineral acid, as free fatty acids are a normal constituent of the so-called "fixed" or fatty oils. Free fatty acids are determined by titrating in an alcoholic solution with a standard potash solution. The "acid number" is another method of expressing free fatty acids and is the number of milligrams of caustic potash required to neutralize one gram of the fat or oil.

### Saponification

Saponification value of an oil is the number of milligrams of caustic potash required to completely saponify one gram of the fat or oil. A low saponification value generally indicates adulteration with mineral oil.

### Iodine Number

Iodine value or number is the number of milligrams of iodine that one gram of a fat or oil will absorb under specific conditions, and for fixed oils the iodine value is usually fairly constant, marked variation indicating adulteration.

### Purchase of Oils and Cutting Compounds Under Specification

When the quantity of oil or cutting compound used is large enough so that expenditures for this item run into considerable sums during the year, it is good practice to have definite specifications under which purchases are made. The Navy Department has drawn up specifications for the purchase of oils, soluble oils, and cutting compounds sold in the form of paste. Although these are more complete than those required by the average manufacturer, they are given in order to show the requirements for each of these materials.

## NAVY DEPARTMENT SPECIFICATIONS

### Oil, Lard, Mineral

*Purpose*—To be used for machine cutting-tool lubricant, either unadulterated or compounded with mineral oil or soda and water.

*Composition*—To be clean and homogeneous; free from disagreeable odors, rancidness, sediment, or ingredients injurious to persons handling the material; and to be easily soluble and retain oily consistency in kerosene or soda and cold-water mixtures. To have a specific gravity at 15 degrees C. of about 0.90, a flash point in an open tester of not less than

180 degrees C., and flow at 4 degrees C. To contain not less than 25 per cent and not more than 35 per cent fixed saponifiable oils, from 60 to 70 per cent mineral, and not more than 5 per cent free fatty acid (calculated as oleic acid).

*Viscosity*—Measured in a Saybolt viscosimeter (with thirty seconds water rate at 15 degrees C.) the oil to show about 185 seconds at 38 degrees C. and 115 seconds at 48 degrees C.

*Gumming*—A saucer with enough test oil to cover the bottom when placed in an oven at a constant temperature of 120 degrees C. for a period of eight hours, when taken out and permitted to cool gradually, shall show no signs of a gummy residue.

*Corrosion*—Strips of polished steel to show no appreciable corrosion in two weeks' time when partly immersed in samples of the oil, or in a mixture of the oil and kerosene, or in an emulsion of the oil, soda, and water.

*Physical Test*—Three gallons of the oil unadulterated will be put into a steel tank and pumped at the rate of one gallon per minute over a steel cylinder heated by an electric coil consuming 440 watts which maintains a constant temperature at 100 degrees C. in air. After a period of three hours the maximum rise of temperature of the oil shall not exceed 30 degrees C.

### Soluble Cutting Oils or Cutting Compounds (Liquid Form)

*Purpose*—To be used in emulsion with water for machine cutting-tool lubricant.

*Composition*—To be a clean and homogeneous mixture of soluble alkali soap in mineral and fixed saponifiable oils. It shall be free from disagreeable odors, sediment, mineral acids, ingredients injurious to persons handling, and shall contain not more than 10 per cent water and not more than 20 per cent soluble alkali soap.

*Emulsification*—To be capable of readily mixing with water in all proportions without the use of sodium carbonate or other addition to form a stable emulsion.

*Lubrication*—The emulsified oil must lubricate turret and automatic machines sufficiently to prevent sticking, and must show no tendency to leave a gummy residue.

*Corrosion*—Strips of polished steel are to show no appreciable corrosion after immersion in the emulsion for two weeks.

*Physical or Cooling Efficiency Test*—When three pints of oil are put into emulsification with three gallons of water and permitted to flow at the rate of one gallon per minute over a steel cylinder heated by an electric coil consuming 440 watts designed to maintain a constant temperature of 100 degrees C. in air for a period of eight hours, the maximum rise of temperature of the emulsion shall not exceed 12 degrees C.

### Cutting Compound (Paste Form)

*Purpose*—To be used for machine cutting-tool lubricant when mixed as directed.

*Composition* — To contain not more than 50 per cent water, not more than 25 per cent mineral oil and between 20 and 30 per cent alkali soap, and the remainder fixed saponified oils. To be free from disagreeable odors, rancidness, or ingredients injurious to handling; and to be easily soluble in water, forming a suitable stable lubricating emulsion which shows no tendency to leave a gummy residue and which will not appreciably corrode strips of polished steel in two weeks' time.

*Physical Tests*—When prepared in an emulsion such as recommended by the manufacturer, and which shall contain not more than 16 pounds of compound and not less than 24 gallons of cold water, it shall lubricate the tool so that in making 1-inch bolts 6 inches long turned to a finished size in one cut from 1⅝-inch hexagonal bar of nickel steel with three inches of chased thread on a turret monitor, with a travel of turret carriage, 6 inches in six seconds and flow of compound, 5 pounds per minute, the following conditions will obtain: The temperature rise of the stock shall not be greater than 35 degrees F., and the standard steel turning or parting tool not to require additional grinding until test is finished on ten bolts. The temperature during this test shall be measured by placing a chemical thermometer on the finished stock within one-half inch of the tool. The standard steel turning and cutting tool mentioned is of tungsten tool steel, class No. 2, in accordance with Navy Department specifications for "tool steel." The hexagonal nickel-steel bars will be in accordance with Navy Department specifications for "hot-rolled or forged nickel steel."

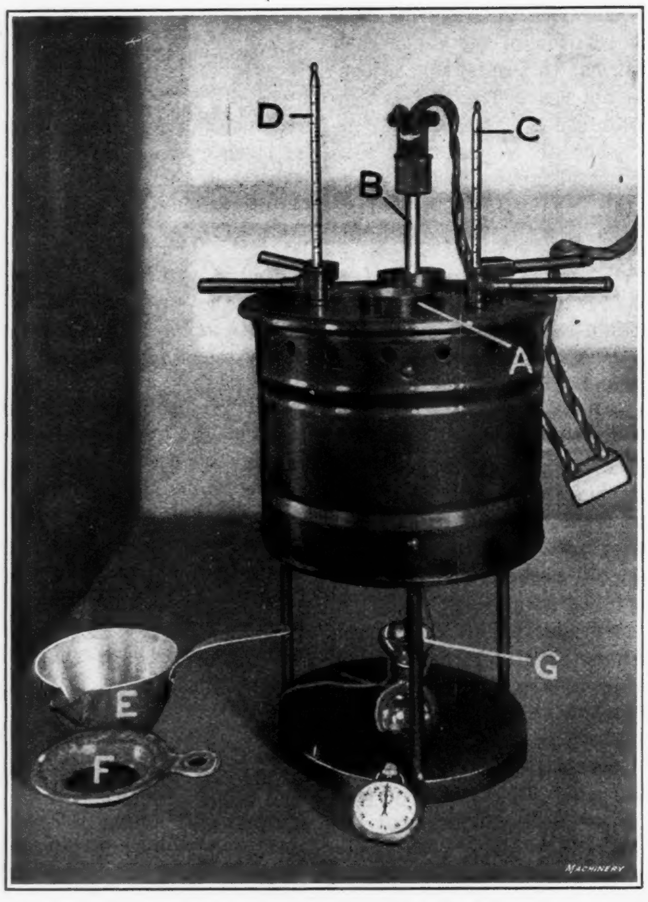


Fig. 72. Saybolt Standard Universal Viscosimeter and Auxiliary Apparatus for determining Viscosity of Oils

### Use of Compressed Air as a Coolant

In milling cast iron and similar operations where the production of short chips makes lubrication of the bearing between the chip and lip of the tool a matter of minor importance, satisfactory results may often be obtained by the use of compressed air delivered to the tool and work in such a way that it absorbs the heat generated by the cut. An advantage of the use of compressed air is that there is absolutely no tendency to gum, and the work is clean and dry when it leaves the machines; also, absence of moisture does away with all danger of rusting the work or machine parts. Fig. 75 shows the method of applying compressed air in milling a typewriter part in the plant of the Royal Typewriter Co., Hartford, Conn. This bar has a slot 7/32 inch wide by 13/32 inch deep milled for its entire length, which is 8¾ inches. The compressed air is delivered through an air line arranged in such a way as to decrease the pressure at the machine to one pound per square inch. At each side of the milling cutters there are pipes *A* bent to the same radius as the cutters; a number of holes are drilled in these pipes, so that air impinges directly upon the milling-cutter teeth. The pressure of the air is not sufficient to cause the chips to be blown around, but the air absorbs heat from the cutters and work, preventing overheating and excessive wear. The slot is finished at a single cut by milling cutters 2¾ inches in diameter which run at 120 revolutions per minute. One piece is finished in one minute, twelve seconds. When finished, the work is sufficiently cool so that it can be picked up and held in the hand.

Fig. 76 shows another example of the application of compressed air for cooling cutting tools. In this case the operation is performed on a Cleveland automatic. The work is a 0.20 to 0.30 per cent carbon machine-steel piston-pin; this is of particular interest because although it is known that compressed air can be used in drilling cast iron with satisfactory results, few mechanics would expect to be able to use it in deep-hole drilling operations in machine steel. The automatic screw machine is fitted up with the regular oil-feed mechanism for the turret tools, but instead of forcing the oil through the piping, compressed air is delivered at a pressure of 75 pounds per square inch. The drill is a regular high-speed steel oil-tube type, with cutting edges ground to break up the chips so that they may be readily removed. So efficient is the compressed air that it is found unnecessary to withdraw the tool until the piece has been completely drilled to a depth of 5 inches, using a feed of 0.015 inch per revolution and a surface speed of 70 feet per minute. This speed is lower than a high-speed steel drill will stand,

but it has been found that a heavy feed with a lower speed gives the best results, as it produces chips which may be easily blown out. The chips are quite cool when they leave the hole and an excellent finish is produced. Before adopting compressed air, lard oil was used for this job, but this proved unsatisfactory due to heating and binding of the drill before the lubricant had reached the bottom of the hole. Apparently the oil made the chips adhere to one another and prevented them from being washed out freely, while with the air the chips are kept clean and cool and are blown out as rapidly as they are produced. This method is used at the plant of the Dayton Motor Car Co., Dayton, Ohio.

### Discovery of Aquadag and Oildag—Compounds Containing Deflocculated Graphite

In 1906, Edward G. Acheson was experimenting with methods of treating carborundum in the electric furnace, and during the course of this work he discovered a small amount of very soft unctuous graphite, which he immediately recognized as an ideal lubricating medium. Commercial methods of making this graphite were developed and patented.

Having developed a method of producing this graphite Mr. Acheson undertook the problem of working out details for its application as a lubricant. His early efforts consisted in using the graphite dry or mixed with grease, the mixture being marketed under the copyrighted name "Gredag." In an effort to extend the field of usefulness of this graphite, experiments were conducted with the view of using the graphite in suspension in different grades of oil, but trouble was encountered by the graphite settling out. In the latter part of 1906, it was found possible to obtain a stable mixture of graphite held in suspension in water, by adding a small quantity of gallotannic acid. This treatment was defined as "deflocculation" and the graphite was called "deflocculated" graphite. The liquid is black and passes easily through the finest filter paper. This mixture of water and graphite was given the name "Aquadag." A valuable property of "Aquadag" is the fact that it does not have any tendency to rust the tools or work. In 1907, Mr. Acheson succeeded in transferring deflocculated graphite from the water medium to an oil medium in which it also remained permanently suspended, and this lubricant was given the name "Oildag." Both these lubricants are made by the International Acheson Graphite Co., Niagara Falls, N. Y.

### Results Obtained with Compounds Containing Graphite

An idea of the efficiency of "Aquadag" and other compounds containing deflocculated graphite may be gathered from the experience of the Niagara Machine Co., Niagara Falls, N. Y. The records showed that the cutting-off tool of a lathe engaged in cutting off cold-rolled steel rods about one inch in diameter required sharpening about every sixty cuts when an ordinary soap cutting compound was used. When "Aquadag" was used to lubricate the tool, the life of the tool was increased to 980 cuts, and the finish was smoother.

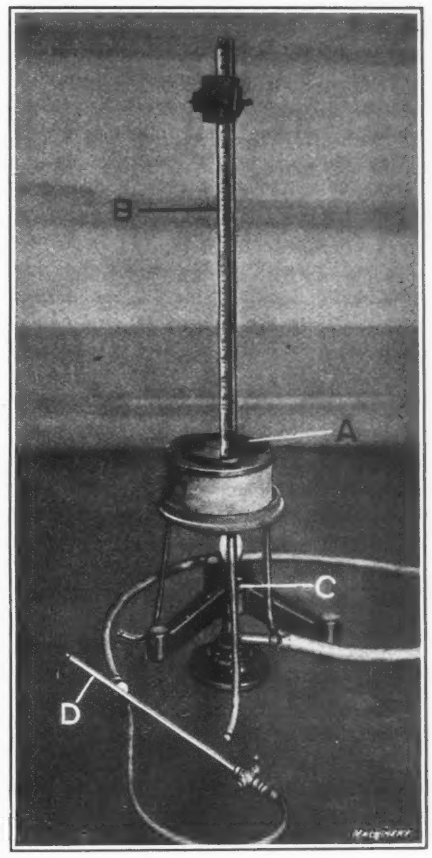

Fig. 73. Cleveland Open Cup for determining Flash Point and Fire Point of Oils

Since its discovery, "Aquadag" has been used for many other machining operations and has given very satisfactory results. For instance, in reaming holes in bronze bushings it was found that an ordinary cutting compound resulted in producing a hole about 0.0002 inch under size, due to the expansion caused by the heat generated by the cut; but when "Aquadag" is used for lubricating, friction and the generation of heat may be so far reduced that there is practically no expansion, and as a result the hole is practically the full size of the reamer. That power consumption is reduced through the use of this cutting compound is demonstrated by the fact that in one factory it was necessary to run a machine on back-gear when using an ordinary cooling compound, but when "Aquadag" was used, it was possible to operate the machine on open belt, thus securing the double advantage of a reduction of power and an increase of speed. This lubricant has been used for boring, cutting off, milling, thread cutting and other operations, and has given uniformly satisfactory results. However, the workmen are prejudiced against its use in spite of the efficient results obtained, as it makes them so dirty.

### Oils Used as Tool Lubricants and Coolants

A great variety of oils are used for lubricating and cooling metal-cutting tools. The selection of a suitable lubricant will depend upon the class of machining operation and the kind of metal being machined, according to the principles explained. Some oils are used pure, notable examples being lard and petroleum oil; in other cases it is desirable to use a mixture of oils in order to obtain a lubricant of the required consistency and of lower cost than pure lard oil, etc.; still another

## TABLE III. PHYSICAL AND CHEMICAL CONSTANTS OF OILS USED FOR LUBRICATION AND COOLING OF METAL CUTTING TOOLS[1]

| Oil | Color | Odor | Appearance | Specific Gravity | Baume Gravity | Flash Point, Degrees F. | Fire Point, Degrees F. | Cold Test, Degrees F. | Saybolt Viscosity at 100 Degrees F. | Free Fatty Acid, Per cent | Acid No. | Saponification Value | Iodine Value | Cost per gallon in 1 Barrel Lots |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neatsfoot Oil | Strong Yellow | Animal Oil | Cloudy | 0.923 | 21.7 | 390 | 460 | 35 | 270 | 18.70 | 37.15 | 197.6 | 56.4 | 1.10 |
| No. 1 Lard Oil | Red Amber | Strong Lard Oil | Cloudy | 0.912 | 23.6 | 398 | 453 | 44 | 182 | 39.71 | 78.84 | 195.0 | 64.4 | 1.00 |
| Extra No. 1 Lard Oil | Yellow | Lard Oil | Cloudy | 0.914 | 23.1 | 440 | 504 | 38 | 203 | 14.24 | 27.33 | 197.9 | 68.1 | 1.05 |
| Sperm Oil | Pale Yellow | Faint | Clear and Bright | 0.882 | 28.7 | 477 | 555 | 35 | 111 | 0.41 | 0.82 | 125.7 | 31.7 | 1.04 |
| No. 3 Bleached Whale Oil | Dark Yellow | Characteristic | Clear and Bright | 0.928 | 20.8 | 494 | 632 | 25 | 191 | 2.13 | 4.21 | 189.1 | 131.8 | 0.77 |
| Fish Oil | Red Amber | Fish Oil | Clear and Bright | 0.927 | 21.1 | 420 | 514 | 23 | 130 | 4.42 | 8.78 | 183.3 | 158.0 | 0.75 |
| Olive Oil | Greenish Yellow | Denatured | Cloudy | 0.916 | 22.9 | 505 | 632 | 10 | 203 | 3.41 | 6.77 | 187.1 | 82.9 | 1.35 |
| Rapeseed Oil | Pale Yellow | Rape Oil | Clear and Bright | 0.916 | 22.8 | 540 | 654 | below 0 | 262 | 2.25 | 4.62 | 172.2 | 100.8 | 1.15 |
| Peanut Oil | Pale Yellow | Peanut Oil | Clear and Bright | 0.918 | 22.5 | 588 | 666 | 35 | 330 | 0.26 | 0.52 | 191.2 | 96.2 | 1.10 |
| Cottonseed Oil | Yellow | Cottonseed Oil | Clear | 0.920 | 22.1 | 476 | 660 | 21 | 168 | 0.21 | 0.41 | 193.0 | 106.4 | 1.10 |
| Tallow Oil | Yellow | Tallow | Solid | 0.913 | 23.4 | 565 | 646 | 88 | 54 (210° F.) | 0.62 | 1.21 | 189.3 | 48.7 | 1.10 |
| 2nd Run Rosin Oil | Red Amber | Rosin | Syrup | 1.056 | 0.8 | 270 | 354 | 24 | 63 (210° F.) | 30.0 | 59.63 | 48.5 | ..... | 0.32 |
| Mineral Lard | Yellow | Fixed Oils | Clear and Bright | 0.882 | 28.8 | 404 | 470 | 20 | 184 | 2.87 | 5.71 | 45.6 | 43.1 | 0.46 |
| Penn. Petroleum | Red Amber | Mineral Oil | Clear and Bright | 0.878 | 29.5 | 395 | 442 | 30 | 189 | ..... | ..... | ..... | ..... | 0.27 |

*Machinery*

[1] Values determined by tests conducted by Charles V. Bacon, consulting chemist of New York City. Care was taken to select samples of oils that were pure and representative of average quality obtainable in the market at the present time.

application is in the compounding of so-called soluble oil mixtures that are diluted with water to form the cutting emulsions.

There are three chief classes of oils, namely animal oils, vegetable oils, and mineral oils. As their name implies, animal oils are extracted from the fatty tissues of certain animals and fish; vegetable oils are obtained from the fruits or seeds of numerous plants. Both of these are known as "fixed" oils, because they cannot be vaporized or distilled when heated without undergoing chemical decomposition. This distinguishes such oils from the "volatile" oils, which may be readily distilled by the application of heat without being decomposed. These are known as mineral oils because they are obtained from petroleum or rock oil. Certain vegetable oils when exposed to the air absorb oxygen rapidly, forming an elastic varnish-like film, and on this account they are known as "drying" oils, of which linseed oil is the best known example. Other vegetable oils show no tendency to form such films and are known as "non-drying" oils. There is a third class, called "semi-drying" oils, which comes between the two preceding classes. Either non-drying or semi-drying oils may be used for cutting lubricants. All fixed oils contain a certain amount of fatty acids, and if allowed to stand in the air this increases and the oil becomes rancid. It is not within the province of this article to enter into a discussion of the chemistry of oils, but it will be of interest to explain briefly the methods used in obtaining the more important classes of oils used for lubricating and cooling cutting tools.

*Cottonseed Oil*—This oil gives good results when used pure for lubricating taps and threading tools, etc. It is also used as a constituent of some mixed oils and cutting compounds. As its name indicates cottonseed oil is obtained from the seeds of cotton plants, extraction being effected by the application of pressure. The presence of dark brown cell materials in the kernel imparts a deep red color to the oil as it runs from the press, this color depending largely upon the freshness of the seeds. The crude oil is refined by treating it with a weak solution of caustic soda, which reduces the color to a pale yellow or light brown. The best grade is known as "prime summer yellow" and should be free from water and possess a sweet flavor and odor. A second grade, known as "summer oil" will become cloudy and partly freeze at a comparatively high temperature, a fatty material separating out, which is known as stearine. By suitable treatment, cottonseed oil may be made to remain perfectly clear at 32 degrees F. for a considerable length of time; oils of this grade are known as "winter oils"—either "prime winter white" or "prime winter yellow." Cottonseed oil comes in the "semi-drying" class.

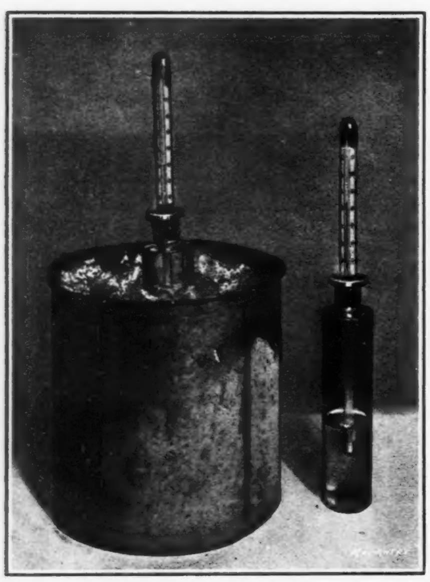

Fig. 74. Cold Test Apparatus with One Bottle in Place and One standing beside Freezing Mixture Container

*Fish Oils*—These oils are more extensively used in the heat-treatment of steel than in lubricating. As implied by its name, menhaden oil is obtained from menhaden, which are somewhat larger than herrings. In extracting the oil, the fish are placed in boiling pans and treated with steam which digests the flesh in such a way that after standing for some time oil rises to the top of the water and is skimmed off. The color of this oil depends upon the freshness of the fish from which it is extracted and upon the length of time that the boiling process is continued. The darker grades of oil are obtained when the boiling process is conducted for too long a time or when the fish is putrid. The crude oils vary in color from yellow to brown, but are bleached in the process of refining to almost a pure white. Unfortunately, various grades of fish oil are often substituted for menhaden oil. These are extracted from many kinds of fish by a method similar to that described. All fish oils are characterized by their distinctive odor, which is likely to be very rank in the case of dark colored oils.

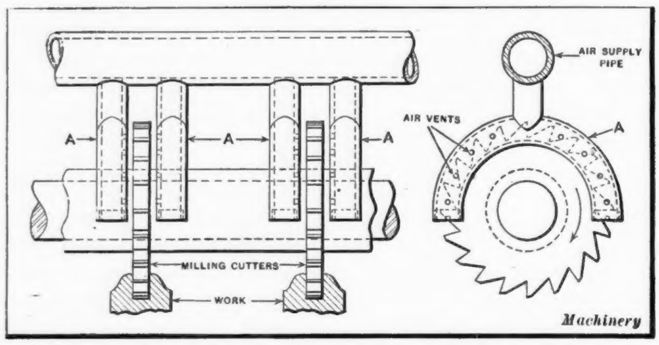


Fig. 75. Method of cooling Milling Cutters with Compressed Air

*Lard Oil*—This is one of the most generally used cutting lubricants, and is either used pure or as a constituent of oil mixtures or cutting compounds. The best grade of lard oil is extracted from layers of fat, known as "leaves," taken from the loins of the hog. This fat is placed in cloth bags and subjected to hydraulic pressure which squeezes out the oil. Other grades of lard oil are obtained by boiling in water the fats and tissues surrounding the abdomen. The lard is skimmed from the surface and kept warm for several hours to allow the tallow to crystallize, this process being known as "seeding." The seeded lard is then put into cloth strainers and subjected to hydraulic pressure which produces the lard oil of commerce. Lard oil may be of the following grades: "Prime winter strained," "prime," "off prime," "extra No. 1," "No. 1," and "No. 2," depending upon the class of material from which it is extracted. Judged from the standpoint of users of cutting lubricants, the chief difference between these lies in the percentage of fatty acid, which may run as high as 30 per cent in the case of a very poor grade of oil. This is a severe detriment on account of the corrosive action exerted by this acid on the work—notably in the case of brass products—and on the bearings of machine tools. To give satisfactory results lard oil should not contain over 15 per cent of fatty acid. Depending upon the temperature and pressure employed in its preparation, the "cold test" or temperature of solidification varies greatly, so that some grades of lard oil will deposit a fatty material, known as stearine, at ordinary room temperature and become stiff at 50 degrees F. High grades of lard oil will remain clear at much lower temperatures. The colors of lard oil range from practically water white to a deep brown, oils of darker color being the inferior grades.

*Neatsfoot Oil*—As a cutting lubricant, neatsfoot oil is recommended for use on broaches—especially when working on very hard material. Neatsfoot oil is generally understood to be obtained from the feet of cattle, but the commercial oil sold under this name is also extracted from the feet of sheep, hogs, horses, and other animals. Extraction is carried on in the following way. The feet are scalded with boiling water to loosen the hoofs, which are then pulled out and the feet are boiled for eight or ten hours. Oil rises to the surface of the water and is skimmed off from time to time, being poured through a screen to separate as much as possible of the suspended matter, after which the oil is dried with steam pipes and filtered. The purpose of removing the hoofs from the feet is to prevent darkening the color of the oil. If proper care is taken in its preparation, neatsfoot oil is low in fatty acid—generally less than ½ per cent—but commercial oil of poor grade may contain as much as 25 or 30 per cent. Neatsfoot oil is of a yellow color and it flows freely.

*Olive Oil*—Some people recommend olive oil as a substitute for lard oil for lubricating cutting tools. It is said to flow more freely and give less trouble through becoming thick in

cold weather. Olive oil costs more than lard oil, but it is said to be a highly efficient lubricant and the amount of oil carried away by chips is less than is the case with lard oil. This oil is extracted from olives and is sold in many different grades, the best of which—known as "edible oil"—is obtained from hand-picked olives. These are crushed in a mill without breaking the seeds, and after separating the fruit from the seeds the oil is extracted in a hydraulic press. A second grade of oil is obtained by pouring cold water over the pressed fruit and subjecting it to a second pressing operation, after which the pulp is once more mixed with hot water and again

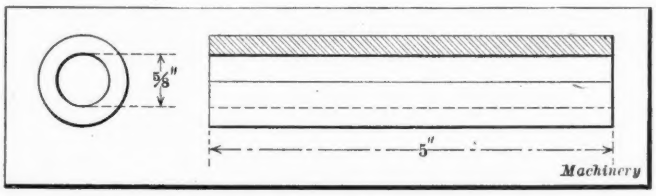


**Fig. 76. Machine-steel Piston-pin drilled with Compressed Air as Coolant**

pressed to yield a third grade of oil. The color of olive oil varies from pale greenish yellow to a dark olive green; as the coloring matter is extracted from the olives with the oil, the lower grades have the highest color. These grades are inferior for use as lubricants, because their high fatty acid content tends to give trouble from gumming and corrosion. Olive oil is a "non-drying" oil.

*Petroleum Oil*—Mixed with lard oil in various proportions, petroleum finds application as a constituent of the well-known cutting lubricant known as "mineral" lard oil. It is also employed in the soluble oil compounds; and for such machining operations as milling and drilling it may be used pure. Crude petroleum oil is obtained in many parts of the world, notably in the states of Pennsylvania and Texas, in Mexico, and in Southern Russia. Crude oil, as it comes from the wells, carries considerable suspended mineral matter which must be removed. As previously mentioned, petroleum oil is of the so-called "volatile oil" type, and is refined by distilling. The stills are heated at different temperatures in order to divide the oil into "fractions" of various composition. Important among these are naphtha, gasoline, and kerosene, which are obtained at the lower temperatures; then come the different grades of lubricating oils and greases that are secured by the successive application of higher temperatures. The color of those grades of petroleum oil used as cutting lubricants is dark yellow or light brown.

*Rapeseed Oil*—As a constituent of certain oil mixtures and cutting compounds, this oil finds a limited application in machine-shop work. It sometimes goes under the trade name of "Colza" oil and is extracted from rape seed. This is a "semi-drying" oil; the color is pale yellow and it has a high viscosity and flows slowly.

*Rosin Oil*—This oil is used as a constituent of certain cutting compounds. It is obtained by subjecting rosin to a process of destructive distillation. This consists of heating rosin in a retort to a temperature sufficiently high for it to be decomposed, allowing vapors to be driven off; among these are the vapors of rosin oil. This process is carried on in cast-iron stills which hold charges ranging from three to five tons. Crude rosin oil is a brown viscous liquid with a characteristic odor and noticeable luminescence of a bluish or violet tinge. When kept at a temperature of 300 degrees F. for several hours the crude oil loses about 4 per cent of its more volatile constituents and assumes a green luminescence which, however, can be removed by chemical treatment, giving a finished oil of a pale brown color. Rosin oil is a "drying" oil, and is not suitable for use as a lubricant except as a constituent of certain mixtures.

*Sperm Oil*—Toolmakers of the old school still regard sperm oil as the best possible cutting lubricant for difficult machining operations, but its scarcity and high price limit the use of this oil to relatively few shops. Sperm oil is extracted from the contents of the head cavity and several smaller receptacles throughout the body of the sperm whales. During the life of the animal the contents of these cavities are in a fluid condition, but no sooner has this "head matter" been removed than white crystalline flakes of wax, known as spermaceti, separate out, leaving a clear yellow fluid possessing a distinctive fishy odor. This sperm oil is the lightest and most fluid of all the fixed oils. An inferior grade of sperm oil is obtained from the blubber of sperm whales. Practically all sperm oil is extracted on shipboard and the crude oil is delivered to refineries, where it is placed in tanks and chilled to 32 degrees F. and allowed to stand for a couple of weeks to freeze out the spermaceti. The semi-solid mass is placed in cloth bags and subjected to hydraulic pressure which squeezes out the oil known as "winter sperm." The material left in the bags is warmed to 50 degrees F. and again pressed to obtain "spring sperm oil." A third quality of oil, known as "taut pressed sperm oil," is obtained by further pressing at higher temperature. Refined sperm oil is of a pale yellow color and has only a faint odor. Certain grades of fish oil and whale oil are often sold for sperm oil.

*Tallow and Tallow Oil*—These materials are sometimes used in making cutting compounds. Tallow is the general name applied to the fat of certain animals; an adjective preceding it indicates the source, as beef tallow is obtained from cattle, mutton tallow is obtained from sheep and goats, etc. The process of melting out the fat from the tissue and membrane is generally carried on in large kettles heated by live steam. At temperatures from 60 to 80 degrees F., tallow is a mixture of solid and fluid fats, and if subjected to pressure the fluid can be separated, tallow oil being the name applied to this liquid. Beef and mutton tallow are similar in general characteristics, and as regards their application for commercial purposes the term "tallow" may indicate either one. Tallow is white and the color of tallow oil is pale yellow.

*Whale Oil*—As a cutting lubricant, whale oil finds application in making cutting compounds and as a constituent of mixed oils. The best grade of whale oil, known as "train" oil, is extracted from the blubber of Arctic or Greenland whales, but the whale oil of commerce is obtained from many species of whales. Some whale oil is extracted on shipboard, and the crude oil is delivered to refineries on the coasts. The blubber of a large whale will sometimes yield as much as 7500 gallons of oil, while a small whale will only yield from 50 to 100 gallons. The best grades of whale oil are obtained from the first boiling, after which the blubber is subjected to a

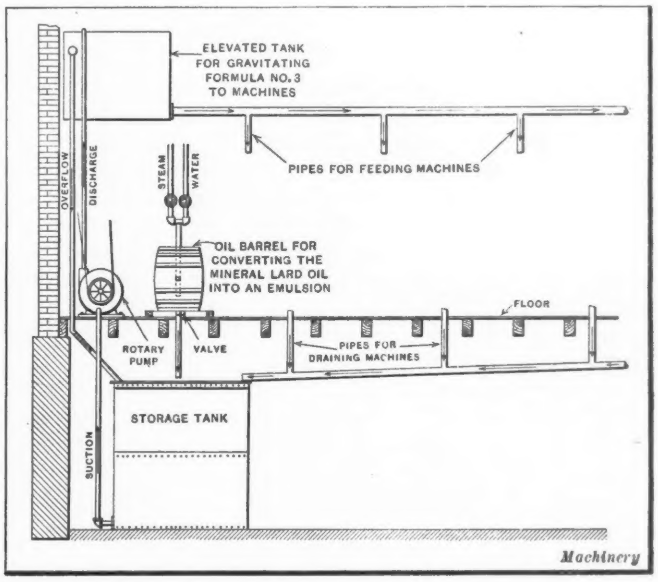


**Fig. 77. Barrel for mixing Soluble Oils and Cutting Compounds with Water—Note Arrangement of Steam and Cold Water Pipes and Drain Pipe for delivering Compound to Storage Tank**

second treatment, which yields a slightly inferior oil. These are known as No. 0 and No. 1, respectively. A third grade of oil is extracted from the residual blubber and flesh of the whale. Even the best grades of this oil have marked drying properties, making them unsuitable for use as a lubricant in the original condition. The color varies from white to yellow, according to grade, and is a fairly reliable indication of quality.

# EXAMPLES OF EXPENSIVE TOOL DESIGNING

## SOME DESIGNS IN WHICH A LITTLE FORETHOUGHT WOULD HAVE SAVED MONEY

BY F. B. JACOBS [1]

ANYONE conversant with up-to-date manufacturing methods realizes that tool designing is a comparatively expensive branch of engineering, and the mistakes of the tool designer often have a far-reaching effect. No one realizes this better than the toolmaker himself. As a practical illustration of the cost of faulty design, a few simple operations observed in several up-to-date tool-rooms are here described.

The box jig illustrated in Fig. 1 is for drilling and reaming four holes in a ring that is held on a pilot made integral with the base. This design made the machine work difficult, because the space between the pilot and the front and back sides of the jig was only 5/8 inch, which prohibited the use of an ordinary left-hand half-diamond-point tool. With a tool of this kind, the pilot could have been finished in a half hour's time after the job was set up. Owing to lack of clearance, the ends of the jig struck the bottom of the tool, so that it was necessary to use a specially made light, square-nose tool held in a boring-tool holder. It took one hour to hunt up stock and make the tool, and four hours to finish the job. Five hours' time against a half hour at a rate of fifty cents per hour shows a deficit of \$2.25. To be sure, \$2.25 is not going to make or break any concern, but when this amount can be saved on one simple operation by a little thought on the part of the designer, the error is inexcusable. By making the jig 1½ inch longer, which would have allowed ample clearance, \$2.25 would have been saved. A still better way would have been to make the pilot of a separate piece of steel and fasten it to the jig base by screws and dowel-pins. In this case all the surfaces could have been finished on the shaper, which would eliminate setting up the piece on the lathe faceplate.

In a jig of this type it is necessary for the bushing plate to fit the jig body accurately, as the bushings and pilot are on separate pieces. There are four fitted surfaces on the bushing plate illustrated, and to machine them accurately they were done with the periphery of a small end-mill, all four surfaces being machined at one setting. Notwithstanding the fact that the superfluous stock was removed by a previous operation, the finishing operation consumed two hours. If the jig had been designed a little wider, to allow for a straight bushing plate, the fitted surfaces could have been finished on

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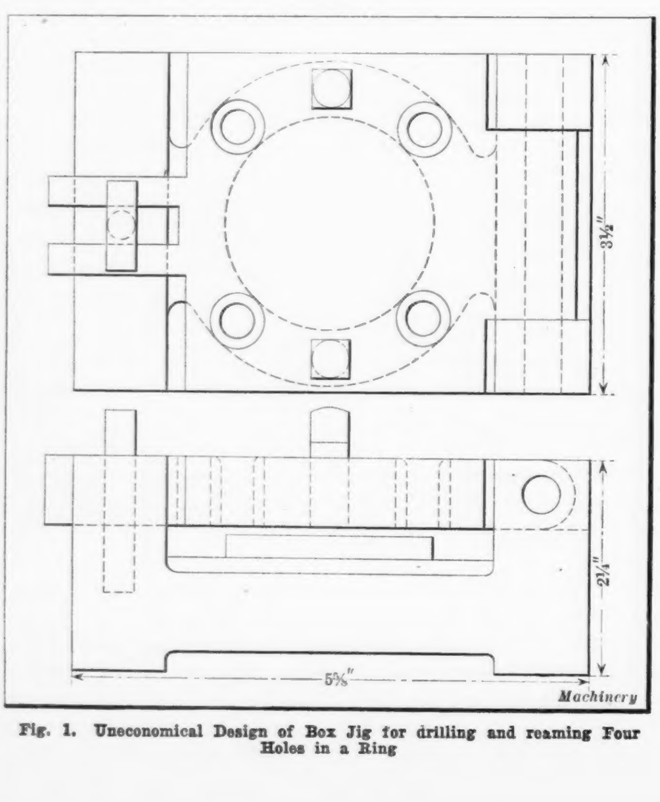


Fig. 1. Uneconomical Design of Box Jig for drilling and reaming Four Holes in a Ring

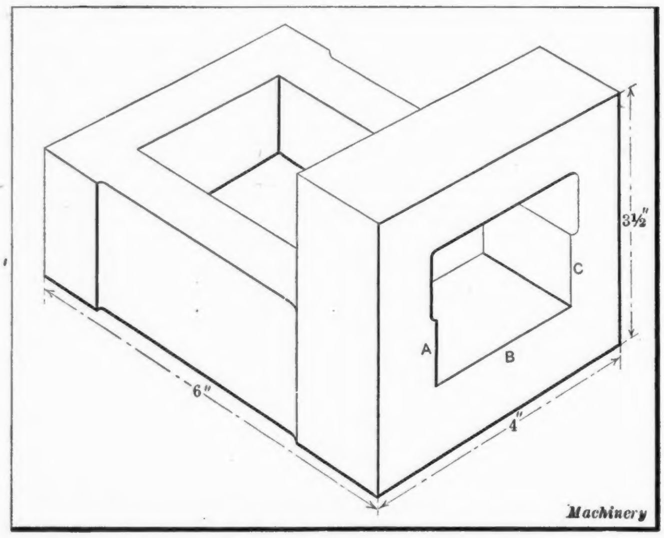


Fig. 2. Jig Casting with Solid Bridge for Set-screw

the shaper in a half hour's time. Thus the work required on this part of the jig cost seventy-five cents more than it should have, figuring on a basis of fifty cents per hour.

In a jig with an accurately fitting bushing plate, it is necessary to bore the hole for the hinge pin, for if the job is done otherwise, a slight error will cause a cramping action due to poor alignment. Why the average tool designer persists in specifying small hinge pins is a question that has never been satisfactorily answered. In this case the hinge pin called for was 3/8 inch. The hole was bored on the milling machine to within 0.002 inch of the desired size and then reamed with a hand reamer 0.001 inch under size to allow for a drive fit on one end of the pin, the remainder being filed to a slip fit. The toolmaker could not find a suitable small boring-bar, so he made one, which took an hour. Owing to the small size of the hole, several very light chips had to be taken with a fine feed, which brought the total time of finishing this work to two and one-half hours. Had the specifications called for a larger hinge pin, say 5/8 inch, heavier cuts could have been taken, making it possible to finish the hole in an hour. Thus it is seen that this slight error cost seventy-five cents.

The bushing plate in question was made of steel, finished very accurately. This was, of course, necessary, for if the buttons for truing up the holes before boring were set on a surface that was out of parallel, accurate results could not be guaranteed. It took three hours to plane the bushing plate, which is altogether too much. If the plate had been made of cast iron, with bosses cast for the buttons, the planing could have been done in an hour; the extra two hours spent add another dollar to the unnecessary part of the cost of the jig. Thus it is seen that \$4.75 was the cost of a few slight errors. If the jig had been designed properly, the average toolmaker would have experienced no difficulty in completing the work in thirty-eight hours, which is a very fair estimate and allows him plenty of time to gossip at the tool-crib window and to make a few shop calls. Thirty-eight hours at fifty cents per hour equals \$19; and as the cost of the errors is one-fourth this amount, the jig cost 25 per cent more than it should.

In an attempt to lessen the number of parts of a jig, the tool designer often makes unnecessary work for the toolmaker. An illustration of this is shown in Fig. 2, which represents a jig casting with a solid bridge over the top for the purpose of carrying a set-screw for holding the work. Owing to the solid construction, the surfaces *A*, *B* and *C* had to be planed by means of a reach tool, which is always comparatively slow cutting; and as three settings were necessary, five hours was consumed in finishing these surfaces. In this case, the bridge should have been made of a separate piece of cold-rolled or ma-

chine steel fastened in place by means of two fillister- or hexagon-head cap-screws; then all three surfaces could have been finished at one setting and in one hour. In some cases a solid form of construction is to be recommended, but the tool designer should consider carefully the amount of machine work necessary to execute his designs before putting them down in black and white.

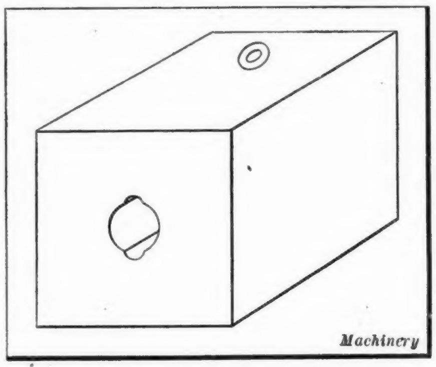


Fig. 3. Simple Jig for drilling Cotter-pin Hole

In Fig. 4 is shown a handy form of jig for drilling a small cotter-pin hole in the piece shown to a larger scale at *A*. Jigs of this kind are excellent for some purposes, as they are comparatively cheap and quickly operated. In this instance, however, it is a case of too much jig for a very simple operation. To be sure, the jig looks simple, as it consists of two plates, with the upper one hinged, and two jaws to grip the work. As a matter of fact, it represents about fifteen hours' work for the average toolmaker. For this particular operation a more satisfactory jig is illustrated in Fig. 3; this is nothing more nor less than a block of steel with a hole drilled in it for receiving the work and a hole for guiding the drill. The larger hole is slightly relieved at the top and bottom, as otherwise the burr thrown up by the drill would make it difficult to remove the piece. The hole for the drill is countersunk at the top for starting the drill readily. This jig can be made of a piece of cold-rolled steel and protected against wear by case-hardening. As the hole for the drill does not have to be located any nearer than within 0.005 inch of the required dimension, this jig can be made by any toolmaker in an hour, and, furthermore, it is much easier to operate than the one previously shown, as the action of holding the jig in the hand keeps the shoulder of the piece against the locating surface. This jig would drill several hundred thousand pieces before wearing out, in which event it could be replaced at slight cost.

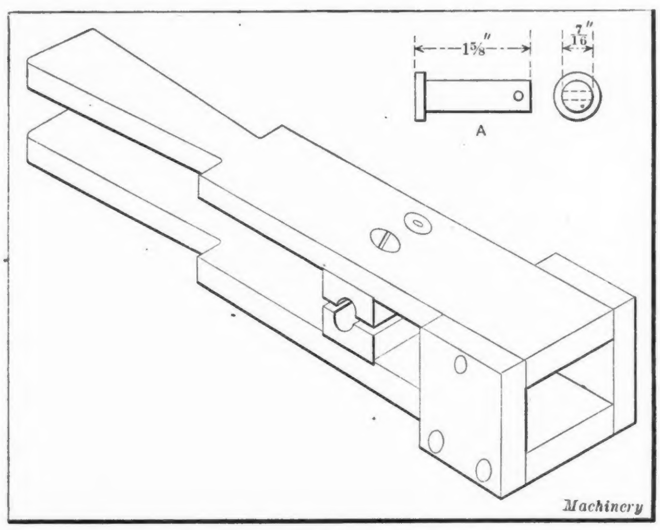


Fig. 4. More Costly Form of Jig than that shown in Fig. 3 for drilling Cotter-pin Hole

The built-up design of jig illustrated in Fig. 5 is sometimes employed even in well regulated shops. It is a costly form of construction, as many pieces have to be fitted accurately. In the jig shown, the body is made of four pieces; the baseplate, two end pieces, and the ledge under the front of the bushing plate. As it is necessary to finish each piece all over, there is at least nine hours' work on the shaper, besides an hour's work in assembling. If the body were cast in one piece, it would be a comparatively easy matter to finish it in four hours. Built-up jigs are generally ordered when the management is in a hurry, or thinks it is, which is the same thing as far as the tool-room is concerned. To be sure, this construction saves the patternmaker a little time at the expense of the tool-room, but there is no ultimate saving, and as the design in question offers no real advantages, it seldom finds favor with up-to-daté designers. At best, it is a relic of the days when toolmakers made jigs to suit themselves; and as this form of jig could be finished all over and then elaborately ornamented by scraping, it was a general favorite with the toolmakers of a quarter of a century ago. When we are in a hurry the temptation to "start something" right away is great,

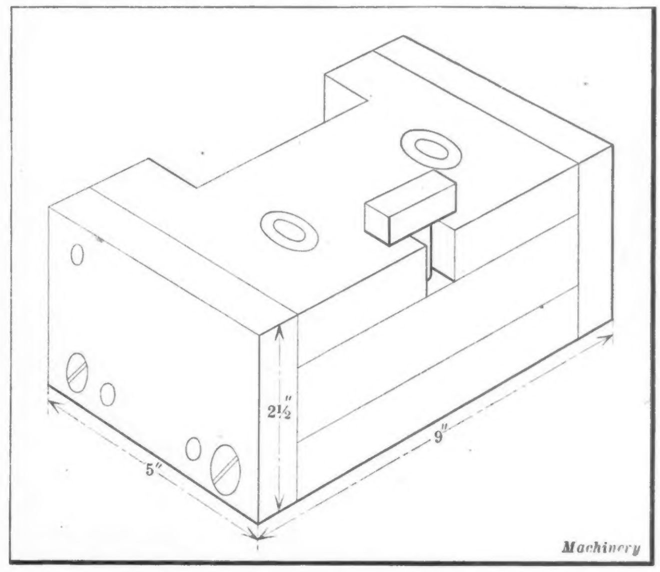


Fig. 5. Costly Built-up Jig

and often results in throwing an unnecessary burden on the tool-room. As 90 per cent of these so-called "hurry jobs" generally result in tools far below normal in efficiency and away above normal in cost, it is best to plan carefully and proceed in the regular way. It is the writer's opinion, based on many years of experience in the manufacturing world, that fully one-half the so-called "hurry orders" for tools are purely imaginary. It is common for managers to put through hurry orders for tools which, after they are completed, often lie on the toolmaker's bench for several days, and sometimes weeks, before being used.

Needless expense caused by inefficient tool designing may be found even in the case of very simple pieces. A good example of this is illustrated in Fig. 6, which shows a ring nut used on adjustable reamers, counterbores, and similar tools; this nut has four slots milled in its periphery for the accommodation of a spanner wrench. In milling these slots, the toolmaker first puts the dividing headstock and tailstock on the milling machine, if he is fortunate enough to find one vacant. Next he goes to the tool crib for an arbor and cutter, and after the job is set up he proceeds with the milling operation. It requires about one hour to mill the four slots in each of the nuts. Of course, if the toolmaker is fortunate enough to find a nut arbor long enough at the threaded end to hold the two nuts at one setting, the time will be reduced somewhat. As spanner wrenches are hard to find in any shop, these nuts are generally set up by means of a cold chisel, which soon batters them out of shape. A better form is shown in Fig. 7. In this case, four holes are drilled for the accom-

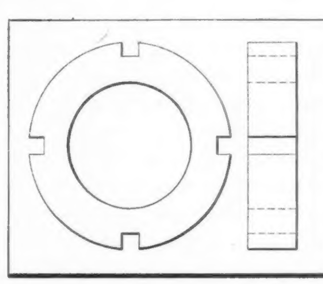

Fig. 6. Ring Nut used on Adjustable Reamers

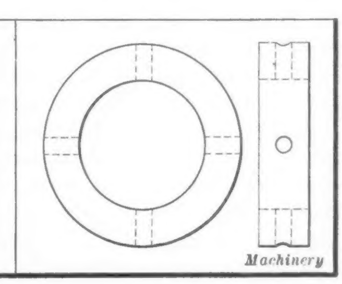


Fig. 7. Improved Form of Ring Nut

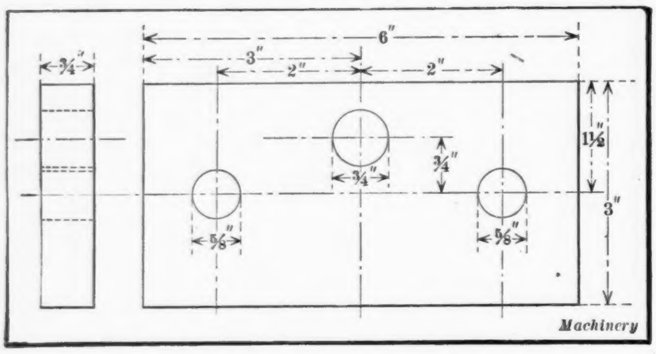


Fig. 8. Simple Piece for which Jig is to be made

modation of a tommy bar, which can be cut off from a rod of cold-rolled steel in a few seconds. As any boy can lay off and drill eight of these holes in a few minutes, it is seen that this design is the more economical in the long run.

Simple jigs can, of course, be constructed cheaper than complicated ones; but it does not follow that the simple jig is the most efficient in service, and this factor brings up a point that must not be overlooked; that is, the tool designer must be informed as to how many pieces are wanted that he may design his jig accordingly. If only six pieces like that shown in Fig. 8 are wanted, it would not be economical to design a jig for this purpose, as the six pieces may be clamped together, strapped to the platen of the milling machine, and all bored at one setting, due care being exercised to see that the spacing of the holes is correct. If fifty pieces are wanted, it would hardly be worth while to design a complicated jig, as a simple templet jig, shown in Fig. 9, will be more efficient than the method of boring on the milling machine. This is

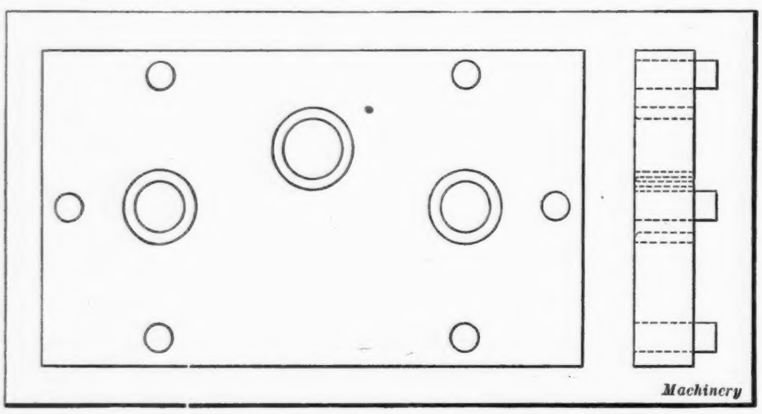


Fig. 9. Suitable Jig for making Piece shown in Fig. 8 in Small Quantities

the simplest form of jig that can be devised, as it consists merely of a plate with bushed holes to provide against wear and a few pins for locating the work. It is fastened to the piece to be drilled by means of two machinist's clamps. If several hundred pieces were wanted, the templet jig would prove too slow, as much time would be lost in clamping the templet to the work; besides, the drilling operation is unhandy, as it is necessary to support the work on parallels. A simple and convenient form of jig for this case is shown in Fig. 10. Here the templet jig is provided with four legs, to eliminate setting the work on parallels, and two quick-acting clamps. However, if a very large number of pieces are to be drilled, say 200,000, it would be economical to design a quick-acting jig, like that shown in Fig. 11. Here the work rests on a hardened pad, to prevent undue wear, and the feet of the jig are provided with hardened ends. Two adjustable screws, set to grip the work when the clamp bar is fastened, hold the work in place, and the clamp bar is fastened by means of an eccentric latch. In comparing this jig with the one illustrated in Fig. 10, it will be found that fifteen seconds is saved in getting the work in and out of the jig. To be sure, fifteen seconds does not amount to much in itself, but when drilling 200,000 pieces, fifteen seconds saved on each piece amounts to 3,000,000 seconds on the whole lot. Three million seconds equals 833 hours, in round numbers, and at thirty cents per hour, which is a fair wage for work of this kind, it means an actual saving of $249.90.

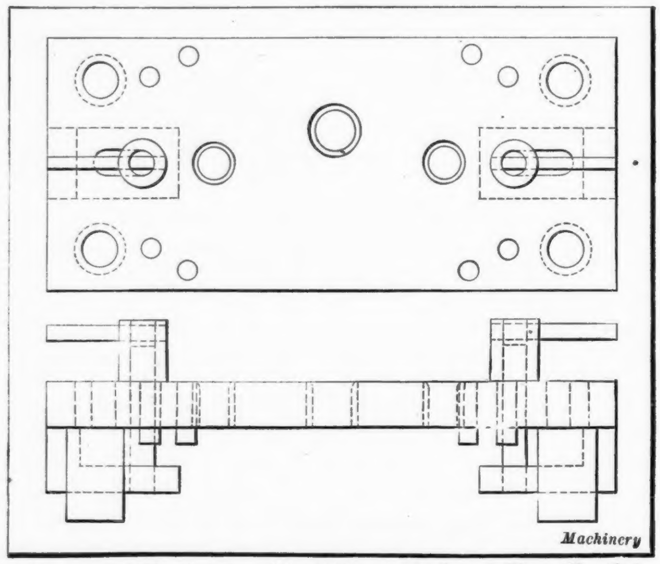


Fig. 10. Suitable Jig for making Moderate Number of Pieces like that shown in Fig. 8

Notwithstanding the fact that the illustrations of poor tool designing shown in this article are simple, they will, no doubt, bring to the mind of the practical man many instances where a saving can be shown by designing efficient jigs. It would not be fair to say that the tool designer must be a practical toolmaker in order to design efficient tools. He should, however, familiarize himself with the rudiments of actual tool-room practice to avoid simple blunders of the kind mentioned. Any toolmaker or tool-room foreman, provided he is a broad-minded man, will not hesitate to point out to the tool designer where money can be saved by designing jigs and fixtures that are readily machined. Tool designing as practiced at present, in the majority of shops at least, is far from efficient, owing to the fact that the men are prone to think that their responsibility ceases as soon as their drawings have passed inspection by the checker. Tool designers, taken as a class, can remedy this defect by spending an occasional hour or so in the tool-room noting actual operations and the time consumed in completing them. By applying the knowledge thus gained in their designs they will add materially to their efficiency.

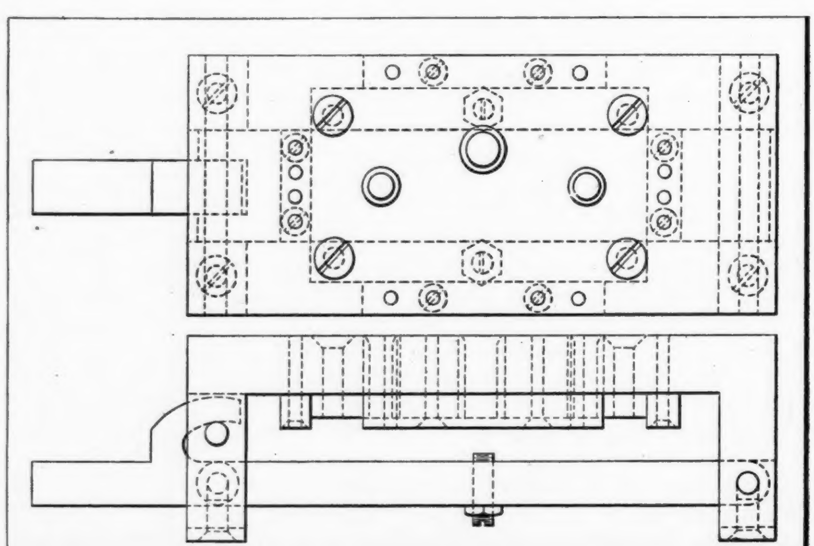


Fig. 11. Jig Suitable for making Large Number of Pieces like that shown in Fig. 8

# INTERNAL BEVEL GEARING[1]

### DESIGNING AND MACHINING INTERNAL AND CROWN BEVEL GEARS OF VARYING- AND PARALLEL-DEPTH TYPES

BY REGINALD TRAUTSCHOLD[2]

THE use of internal bevel gearing is limited to installations in which the included angle between the gear and the pinion shafts (the shaft angle), viewed from the rear of the gears, is appreciably greater than 90 degrees. This gearing is used, therefore, far less frequently than bevel gearing of the common externally meshing type. The pinion cone of revolution, in internal bevel gearing, rolls on the interior surface of the concave gear cone of revolution, while in the more common type of bevel gearing, the pinion cone of revolution rolls upon the exterior surface of the convex gear cone of revolution. The shaft angle, viewed from the rear of the gears, for internal bevel gearing may range from an angle quite appreciably greater than 90 degrees to one approaching 180 degrees, a range of considerably less than 90 degrees. The shaft angle of ordinary externally meshing bevel gears, on the other hand, may range from a comparatively small angle to one approaching 180 degrees, a range more than double that of internal bevel gearing.

Notwithstanding the more limited range of internal bevel gearing, the possibility of securing relatively high speed ratios within a limited space gives this type of transmission an important field—a field that would be more generally recognized and more thoroughly covered if the design of internal bevel gears were more commonly understood. Failure to recognize the adaptability of internal bevel gearing is quite probably due to an unfortunate practice, which has become almost universal, of designating the shaft angle in a different manner from that employed for the designation of the shaft angle for externally meshing bevel gears. In the common variety of bevel gears, the shaft angle is correctly designated as the sum of the center angles of the gear and pinion, as shown in Fig. 1; but in internal bevel gearing, the shaft angle is usually designated as the angle measured by the difference between the center angles of the gear and the pinion. Actually, the included shaft angle—the true shaft angle—is not measured directly by the difference between the center angles of the gear and the pinion, but by the supplement of the angle measured by such difference, as can be seen by referring to Fig. 1.

[1] For other articles on internal gearing, see "Internal Helical Gearing" in the February, 1917, number of MACHINERY and "Internal Spur Gearing" in the January number.

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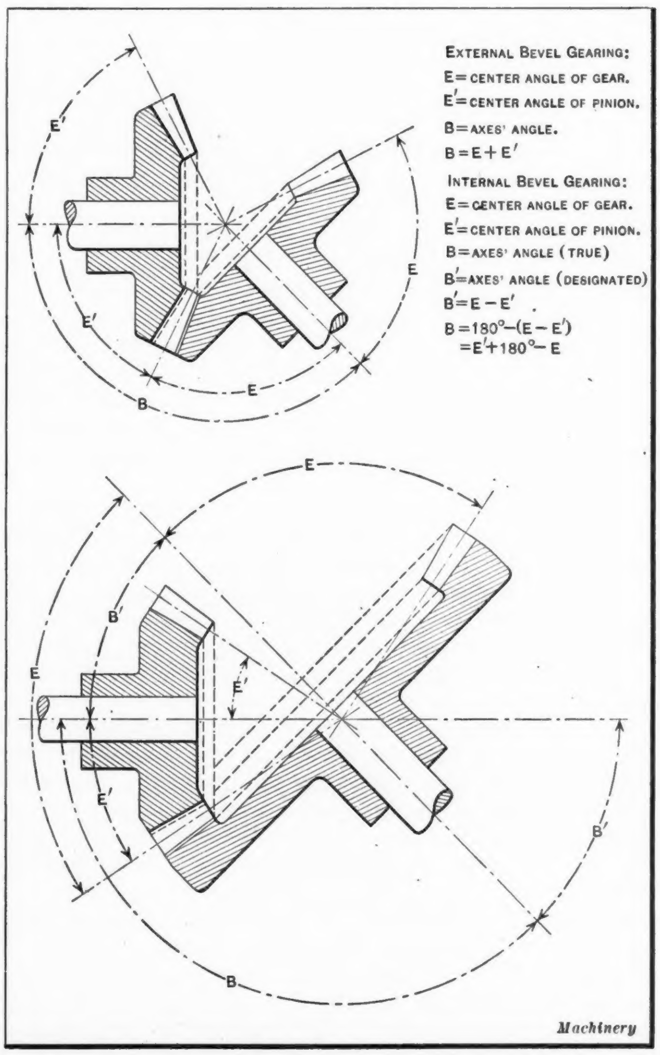


Fig. 1. Relation of Center Angles to Angle of Axes

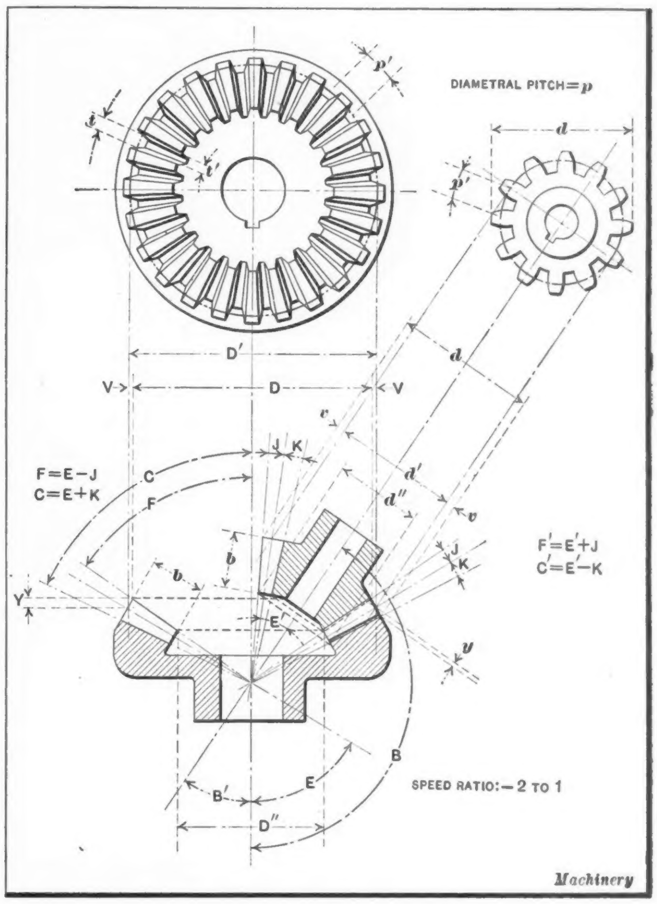


Fig. 2. Typical Internal Bevel Gears

But for the fact that the true shaft angle must necessarily be obtuse in internal bevel gearing—that is, the included angle between the gear and the pinion shafts must be greater than 90 degrees—the calculations involved in the design of internal bevel gearing are no more complicated than those required in laying out the more common variety of externally meshing gears. The tooth proportions do not differ in any way from those of ordinary bevel gears, being on the octoid system, as only such form can be practically conjugated by bevel-gear generating machines. In the formulas that will be presented for the derivation of the center angles, the supplement of the true shaft angle—the "designated shaft angle"—is employed, notwithstanding the fact that this may tend to a certain confusion, as the formulas are thereby simpler in form and more conveniently applicable.

Fig. 2 illustrates a typical lay-out of internal bevel gearing with the more important dimensions, etc., indicated according to the notation given in the following. The tooth proportions on the outer pitch circle are those employed in designating sizes of gears, as the factors entering the various formulas, etc., unless other dimensions are specifically noted.

### Notation for Internal Bevel Gearing

| | Gear | Pinion |
|---|---|---|
| Diametral pitch | $p$ | $p$ |
| Circular pitch | $p'$ | $p'$ |
| Pitch diameter, outer | $D'$ | $d'$ |
| Number of teeth | $N$ | $n$ |
| Face | $b$ | $b$ |
| Apex distance | $a$ | $a$ |
| Addendum, outer | $s$ | $s$ |
| Clearance, outer | $f$ | $f$ |
| Dedendum, outer | $s + f$ | $s + f$ |
| Depth of tooth, outer | $W$ | $W$ |
| Center angle | $E$ | $E'$ |
| Face angle | $F$ | $F'$ |
| Cutting angle | $C$ | $C'$ |
| Angle increment | $J$ | $J$ |
| Angle decrement | $K$ | $K$ |
| Diameter increment | $V$ | $v$ |
| Backing | $Y$ | $y$ |
| Outer diameter { gear, inner end of teeth / pinion, outer end of teeth } | $D$ | $d$ |
| Inner diameter { gear, inner end of teeth / pinion, outer end of teeth } | $D''$ | $d''$ |
| Thickness of tooth on outer pitch circle | $t$ | $t$ |
| Thickness of tooth on inner pitch circle | $t'$ | $t'$ |
| Speed ratio | $R = \frac{N}{n}$ | |
| Speed ratio reciprocal | $R' = \frac{n}{N}$ | |
| Shaft angle, true | $B$ | |
| Shaft angle, designated | $B'$ | |

### Formulas for Internal Bevel Gearing

$$p = \frac{N}{D'};\ \text{or } p = \frac{n}{d'} \quad (1) \qquad p' = \frac{3.1416}{p} \quad (2)$$

$$D' = \frac{N}{p};\ \text{or } D' = Np'0.3183 \quad (3) \qquad d' = \frac{n}{p};\ \text{or } d' = np'0.3183 \quad (3a)$$

$$\operatorname{Tan} E = \frac{\sin B'}{\sin B' - R'} \quad (4) \qquad E' = E - B' \quad (4a)$$

$$a = \frac{D'}{2 \sin E};\ \text{or } a = \frac{d'}{2 \sin E'} \quad (5) \qquad s = \frac{1}{p};\ \text{or } s = p'0.3183 \quad (6)$$

$$s + f = \frac{1.157}{p};\ \text{or } s + f = p'0.3683 \quad (7) \qquad W = 2s + f \quad (8)$$

$$\operatorname{Tan} J = \frac{s}{a};\ \text{or } \operatorname{Tan} J = \frac{2 \sin E}{N};\ \text{or } \operatorname{Tan} J = \frac{2 \sin E'}{n} \quad (9)$$

$$\operatorname{Tan} K = \frac{s + f}{a};\ \text{or } \operatorname{Tan} K = \frac{2.314 \sin E}{N};$$

$$\text{or } \operatorname{Tan} K = \frac{2.314 \sin E'}{n} \quad (10)$$

$$F = E - J \quad (11) \qquad F' = E' + J \quad (11a)$$

$$C = E + K \quad (12) \qquad C' = E' - K \quad (12a)$$

$$V = s \cos E \quad (13) \qquad v = s \cos E' \quad (13a)$$

$$Y = s \sin E \quad (14) \qquad y = s \sin E' \quad (14a)$$

$$D = D' - 2s \cos E \quad (15) \qquad d = d' + 2s \cos E' \quad (15a)$$

$$D'' = D - 2(b \sin F) \quad (16) \qquad d'' = d - 2(b \sin F') \quad (16a)$$

$$t = \frac{1.5708}{p};\ \text{or } t = \frac{p'}{2} \quad (17) \qquad t' = \frac{t(a - b)}{a} \quad (18)$$

### Discussion of Formulas

The formulas presented for the pinion member of an internal bevel gear combination do not differ in any way from the formulas governing the design of ordinary externally meshing bevel gears. In the case of the internal bevel gear, however, the formulas are radically different and somewhat more complicated, on account of the internal arrangement and the variable center angle of the gear. The latter condition is similar to the varying effect of externally meshing bevel gears having an obtuse shaft angle, complicated by the concave face of the gear.

The center angle of the gear member is found by first ascertaining the tangent of the angle. This is equal to the sine of the designated shaft angle of the combination—the supplement of the angle included between the respective shafts of the gears—divided by the difference between the sine of the designated shaft angle and the reciprocal of the speed ratio. The center angle of the pinion is then readily found, being the difference between the center angle of the gear and the designated shaft angle.

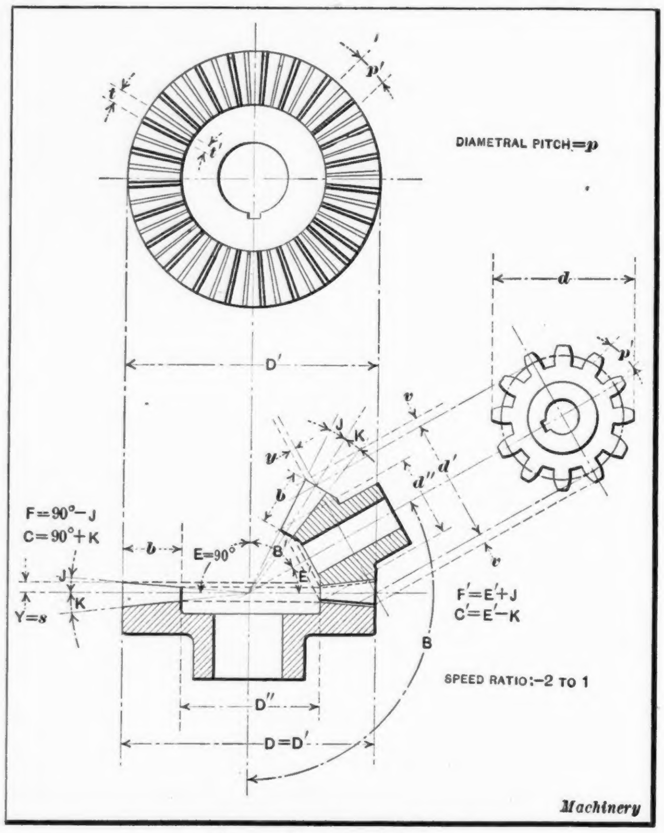


Fig. 3. Crown Bevel Gears

The tangents of the angle increment and decrement are, respectively, the addendum and the dedendum divided by the apex distance, the latter being the quotient of the pitch diameter (outer) divided by twice the sine of the center angle. For standard 14½-degree octoid teeth, twice the sine of the center angle divided by the number of teeth in the corresponding gear or pinion gives the tangent of the angle increment, and the product of the sine of the center angle by 2.314 divided by the number of teeth gives the tangent of the angle decrement.

The face and cutting angles of the internal bevel gear are equal, respectively, to the center angle minus the angle increment, and to the center angle plus the angle decrement, the increase and decrease of the center angle being the opposite of the pinion and ordinary externally meshing bevel gears. That is, the angle increment is subtracted from the center angle to obtain the face angle, instead of being added to that angle, and the angle decrement is added to the center angle to obtain the cutting angle, instead of being subtracted, as for ordinary bevel gears.

The diameter increment of the gear (actually a decrement) is found as usual, being the product of the addendum and the cosine of the center angle. Twice this value is subtracted from the outer pitch diameter of the gear to obtain the outer diameter of the gear—the diameter across the outer ends of the teeth. The outer diameter of the pinion member is equal to the sum of its outer pitch diameter and twice the product of the cosine of its center angle and the addendum.

The inner diameter of the gear—the axial distance between the inner ends of the teeth—is equal to the outer pitch diameter of the gear minus twice the product of the face of the gear by the sine of its face angle. The corresponding pinion diameter is equal to the difference between its outer pitch diameter and twice the product of its face by the sine of its face angle.

The thickness of the teeth of both the gear and the pinion on the outer pitch circles is, as usual, equal to half the circular pitch, or to 1.5708 divided by the diametral pitch; while on the inner pitch circles, the thickness of the teeth is reduced directly with the difference between the apex distance and the face of the gears. That is, the thickness of the teeth on the inner pitch circles is equal to their thickness on the

outer pitch circles multiplied by the ratio of the difference between the apex distance and the face of the apex distance.

### Example in Design of Internal Bevel Gearing

*Example:*—Required, an internal bevel gear combination; 4 diametral pitch, 64 teeth in gear, 20 teeth in pinion, 2-inch face; shaft angle, 135 degrees. $p = 4$, $b = 2$ inches, $B' = 180 - 135 = 45$ degrees, $R' = 20 \div 64 = 0.3125$.

$$p' = 3.1416 \div 4 = 0.7854 \text{ inch} \qquad (2)$$

$$D' = 64 \div 4 = 16 \text{ inches} \quad (3) \qquad d' = 20 \div 4 = 5 \text{ inches} \quad (3a)$$

$$\tan E = \frac{0.70711}{0.70711 - 0.3125} = 1.79192; \qquad (4)$$

$$E = 60 \text{ degrees, } 50 \text{ minutes}$$

$$E' = 60 \text{ degrees, } 50 \text{ minutes} - 45 \text{ degrees} = 15 \text{ degrees, } 50 \text{ minutes} \qquad (4a)$$

$$a = \frac{16}{2 \times 0.87321} = 9.1616 \text{ inches} \qquad (5)$$

$$s = 1 \div 4 = 0.250 \text{ inch} \qquad (6)$$

$$s + f = 1.157 \div 4 = 0.289 \text{ inch} \qquad (7)$$

$$W = 0.250 + 0.289 = 0.539 \text{ inch} \qquad (8)$$

$$\tan J = 0.250 \div 9.1616 = 0.02728;$$

$$J = 1 \text{ degree, } 34 \text{ minutes} \qquad (9)$$

$$\tan K = 0.289 \div 9.1616 = 0.03154;$$

$$K = 1 \text{ degree, } 48 \text{ minutes} \qquad (10)$$

$$F = 60 \text{ degrees, } 50 \text{ minutes} - 1 \text{ degree, } 34 \text{ minutes} = 59 \text{ degrees } 16 \text{ minutes} \qquad (11)$$

$$F' = 15 \text{ degrees, } 50 \text{ minutes} + 1 \text{ degree, } 34 \text{ minutes} = 17 \text{ degrees, } 24 \text{ minutes} \qquad (11a)$$

$$C = 60 \text{ degrees, } 50 \text{ minutes} + 1 \text{ degree, } 48 \text{ minutes} = 62 \text{ degrees, } 38 \text{ minutes} \qquad (12)$$

$$C' = 15 \text{ degrees, } 50 \text{ minutes} - 1 \text{ degree, } 48 \text{ minutes} = 14 \text{ degrees, } 2 \text{ minutes} \qquad (12a)$$

$$V = 0.250 \times 0.48735 = 0.1218 \text{ inch} \qquad (13)$$

$$v = 0.250 \times 0.96206 = 0.2405 \text{ inch} \qquad (13a)$$

$$Y = 0.250 \times 0.87321 = 0.2183 \text{ inch} \qquad (14)$$

$$y = 0.250 \times 0.27284 = 0.0682 \text{ inch} \qquad (14a)$$

$$D = 16 - 2 \times 0.1218 = 15.7564 \text{ inches} \qquad (15)$$

$$d = 5 + 2 \times 0.2405 = 5.4810 \text{ inches} \qquad (15a)$$

$$D'' = 15.7564 - 2(2 \times 0.85955) = 12.3182 \text{ inches} \qquad (16)$$

$$d'' = 5.4810 - 2(2 \times 0.29904) = 4.28484 \text{ inches} \qquad (16a)$$

$$t = 1.5708 \div 4 = 0.3927 \text{ inch} \qquad (17)$$

$$t' = \frac{0.3927(9.1616 - 2)}{9.1616} = 0.3069 \text{ inch} \qquad (18)$$

### Crown Bevel Gears

The transition of bevel gearing from the externally meshing type to internal bevel gearing is marked by the type known as the crown gear; that is, a bevel gear having a center angle of 90 degrees, as shown in Fig. 3. Such gearing can be classified, with equal logic, as of either the external or the internal meshing variety, but the latter is preferable, for its use is quite as limited as that of internal bevel gearing, if not more so. The surface of revolution of the crown gear is resolved into a plane surface from a cone of revolution, so that the pitch diameter of the gear is the same as its outside diameter. The backing of the crown gear—the distance from the outer point of the teeth to the pitch line—is equal to the addendum, and the apex distance is equal to one-half the pitch diameter of the gear.

The center angles of pinions meshing with crown gears are naturally quite different, for a given shaft angle, from those of the pinions in either the ordinary internally or externally meshing bevel gear combinations and are much more easily calculated; the center angle of the crown gear is always 90 degrees. The center angle of the pinion member is equal to 90 degrees minus the designated shaft angle (the designated shaft angle of the crown gear is the true shaft angle of the combination minus 90 degrees—the center angle of the crown gear—) or 180 degrees minus the shaft angle. Obviously, the shaft angle determines the center angle of the pinion and also fixes a definite speed ratio which cannot be varied without changing the shaft angle, and which is considerably less than the speed ratio obtainable with the same shaft angle by the use of internal bevel gearing. For instance, with a shaft angle of 135 degrees, shafts bearing the same relative position to each other as in the example given in the design of internal bevel gearing, the center angle of the pinion meshing with a crown gear will be 45 degrees (90 degrees — $B'$) or (180 degrees — $B$) and the speed ratio will be fixed at 1.414 to 1, the ratio of the pitch diameters of the crown gear and its pinion bearing such relation. In the case of the internal bevel gear combination with a shaft angle of 135 degrees, the center angle of the pinion was but 15 degrees, 50 minutes, and the speed ratio 3.2 to 1.

### Parallel-depth Internal Bevel Gearing

The variation in the depth of ordinary bevel gears, both of the internal and the common external type, seriously complicates machining operations and has led to the development of bevel gears with constant-depth teeth. For internal and crown bevel gearing, this type is shown in Fig. 4. The peculiarity of this type of design is that the center, face, and cutting angles are all equal. The radial pitch lines on either tooth profile alone converge to the common apex point, while the imaginary cones represented by the conical surfaces of the face and cutting planes are similar but normally separated from the pitch cone of revolution by the addendum and the dedendum distances of the gear teeth, respectively.

The true octoid form of tooth, the modification of the involute now universally employed for standard bevel gears on account of the necessity of such form for the successful operation of all kinds of bevel-gear generating machines, can be common to only one point along the length of the various teeth. It has become general practice to make the section of the teeth on the inner pitch circle conform to such standard. This gives to the outer section of the teeth a decidedly squatty appearance, the thickness of the teeth on the outer pitch circle being considerably greater than that of the true octoid tooth of the same depth. With the exception that the angles increment and decrement do not exist in parallel-depth internal bevel or crown bevel gears and that the tooth proportions are figured from the inside pitch diameters of the gears, the formulas presented for the solution of regular standard types of internal bevel gearing apply as well to parallel-depth internal bevel gearing.

### Machining Internal Bevel Gears

Internal bevel gears and crown gears are machined in ways very similar to those employed for ordinary bevels. That is, there are three general processes of machining such gears—milling, planing, and generating. The resulting teeth are more or less exact reproductions of octoid teeth when cut by either of the first two methods, but are of the true octoid form

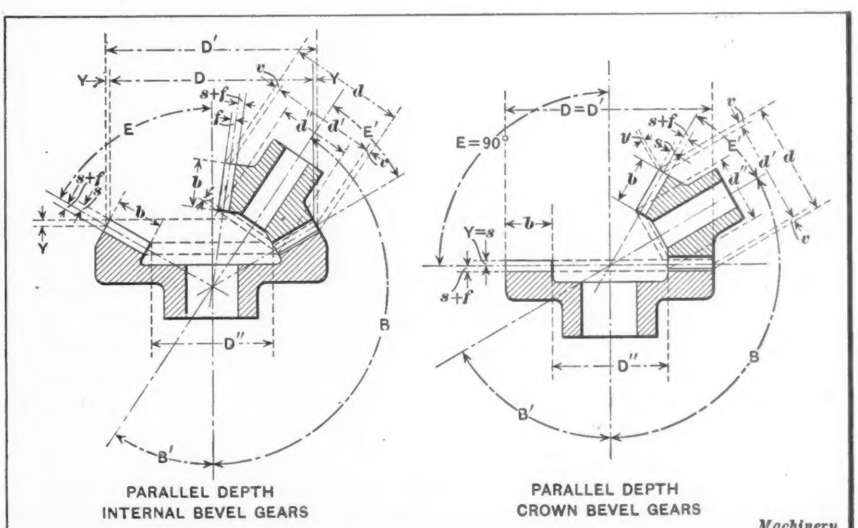


Fig. 4. Bevel Gearing with Parallel Depth Teeth

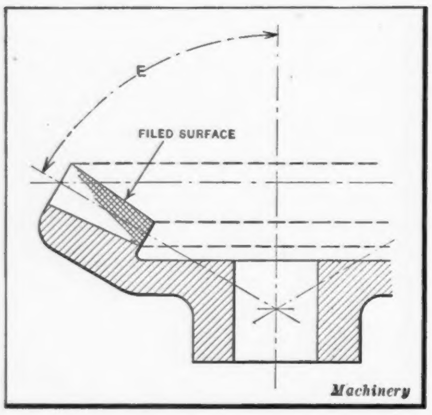


Fig. 5. Filed Surface of Milled Internal Bevel Gear Teeth

only when generated; that is, gears with tapering-depth teeth.

Milling the teeth necessitates five adjustments of the blank, or work: one position for the gashing cuts and two for the finishing cuts on either side. In milling the tapering-depth teeth, the cutter is selected for the outer pitch circle profile, but must be sufficiently narrow to pass through the tooth space at the inner end of the finished teeth. In milling the parallel-depth teeth, the cutter is selected for the inner pitch circle profile and the resulting teeth have a correct profile for the inner end throughout their length, but the depth is more and more disproportional to the true octoid as the outer ends of the teeth are approached.

The ordinary planing process is quite similar to the milling process; but special bevel-gear planing machines are also employed which cut teeth closely resembling the octoid form. These special planers employ three templets for guiding the three simple planing tools used for cutting the teeth. One of these tools, usually of the straight-faced type, is employed only for gashing, the sides of the teeth being finished with specially formed tools, one for each side. All the teeth are finished on one side before the second finishing tool is used.

Generating machines for conjugating the true octoid tooth employ one of two general methods, the planing or the milling process. The machines operating on the planing principle have a crown gear, provided with cutting tools representing its sides in successive positions, which meshes with a master bevel gear carrying on its arbor the gear blank to be cut. The crown and master gears rotate in mesh and present the work to the cutting tools, the work and the cutting tools virtually rolling together to conjugate the teeth. Generating machines employing the milling process differ in having the sides of the teeth of an imaginary crown gear represented by the plane surfaces of milling cutters. The crown gear equivalent is stationary and the master bevel rolls over it, thus presenting the work to the milling cutters in successive positions. Both types of generating machines conjugate true octoid teeth.

### Filing Milled Bevel Gear Teeth

The tooth section of the tapering-depth bevel gears cut on milling machines or by the ordinary planing method is of the correct octoid form only at the outer end of the teeth. The constant cutting profile of the tool leaves an excess of material from the tip of the outer end of the tooth to the full depth of the tooth at the inner end. The excess metal increases from the outer to the inner ends of the teeth, on account of the variation in the depth of the addendum and dedendum of the teeth, which is due to the face, center, and cutting angles being dissimilar. This surplus material must be removed with a hand tool. Usually a file is employed, whether the gears are of the internal or the external type, but the surplus material is removed with much more difficulty in the case of internal bevel gears.

Fig. 5 illustrates the surface of internal gear teeth which has to be cut away in order that the pitch lines of the tooth profiles may correctly converge to the apex center and allow the proper meshing of teeth. The figure also indicates the difficulties which are encountered when filing internal bevel gear teeth due to the awkward position of the teeth for clearance in swinging the file. In filing externally meshing bevels, the machinist is placed in no such position, so that a clear swing can be taken and the task of accurately filing is not particularly difficult for the skilled workman.

### Parallel-depth Bevel Gear Weakness

The parallel-depth design of bevel gearing evades the necessity of filing the teeth, but has one possible drawback in its relative weakness. As the tooth section is of the true octoid form only at the inner end, the remainder of each tooth is of less rugged proportions, notwithstanding the appearance of stubby and powerful design. The thickness of the teeth is correct for full tooth strength throughout the entire length, but the gradual relative decrease in depth, though apparently adding strength, reduces the power much as would the wearing away of the top of the teeth in actual service. This drawback is not a serious one, however, and parallel-depth bevel gears are quite generally considered the equal of gears with teeth of the true octoid form of varying depth. Certainly they are equal, if not superior, to bevel gears of varying tooth depth which are cut on milling machines or ordinary planers and have to be finished by filing or other hand tool operation.

* * *

## SCREW THREAD TOLERANCES

A hearing was held in Washington in February with reference to the matter of establishing by law tolerances, clearances and allowances in specifying screw threads in manufacturing plants under the control of the War and Navy Departments. Bearing on the importance of having settled as clearly as possible all dimensions involved in the production of munitions of war, it has been said recently by an authority as to the experience in Great Britain that there is no doubt that if when the war broke out a more satisfactory system had been in use and gages had been so designed that they could have been cheaply and rapidly produced in quantity, the country would have been saved many thousands of pounds and much delay in the turning out of shells. It is appreciated that in order to bring about the best results in this country in screw thread tolerance practice it is necessary that civilian industrial authorities should be consulted thoroughly as well as officers and engineers of the government, and that moreover the standards settled upon, whether these shall be of one series or of various grades suitable for different classes of workmanship, shall be entirely commercial in regular manufacture. In the formulation of the standards, civilian makers of taps and screws, and also users, will be consulted. Dr. Stratton of the United States Bureau of Standards feels that it is entirely feasible for the industries and the military departments to follow the same practice. It is perfectly obvious that in the time of war this would have to be the case.

Accurate measurement of screw threads in commercial practice has been a slow development. Different societies including the American Society of Mechanical Engineers and the Society of Automobile Engineers, have had committees working on the subject for a number of years. It is felt now, however, that through concerted effort of representative experts in government and civil life the complex questions connected with determining just how accurately screw products can be made commercially must be brought to an early issue, and the government specifications generally acquiesced in, meeting the necessities for the high-grade workmanship which exists, of course, in various apparatus used by the government including airplanes.

* * *

## SUBSTITUTE FOR BABBITT METAL

On account of the scarcity of copper in Germany, determined efforts have been made to substitute alloys containing little or no copper for those containing high percentages. It is stated in *Glasers Annalen* that German metallurgists have succeeded in producing a bearing metal alloy containing a very small percentage of copper, and a fairly small percentage of tin, which has all the properties of the highest grade of bearing metal. The alloy consists of 3.3 per cent copper, 12 per cent lead, 21.3 per cent tin, and 63.4 per cent zinc. The alloy is produced by melting red brass and adding to it first the tin and lead, and finally the required amount of zinc, which before being added to the molten alloy is preheated to about 400 degrees F. The alloy has a hardness of 42 on the Brinell scale.

# LIQUID FUELS FOR HEATING FURNACES

## FIXING VALUE OF FUEL OILS FOR METALLURGICAL FURNACES ON A B. T. U. BASIS

BY GEORGE P. PEARCE [1]

THE oil furnace for heating stock, whether for welding, forging or bending, is most convenient and satisfactory, and if the basic principles upon which its efficient operation depends were better known, there would be an elimination of almost all the usual oil furnace troubles, combined with greater efficiency in fuel consumption and output. Heating stock is a simple process if economy of operation is of no consequence; making a fire on the ground and putting the stock in the hottest part is one of the most primitive acts of man. Today, owing to the ever-increasing keenness of competition, it has become a matter of great complexity to heat stock at the lowest cost.

There are many things to consider in efficient furnace design. Probably the most important is the method of delivering the oil to the furnace with the least amount of air that will properly burn it. Most of the oil burners operate on the atomizing principle, that is, they mechanically break up the oil stream into innumerable particles or globules which greatly increase the exposed area and thus accelerate combustion. The efficiency of this type of burner is inversely proportional to the size of the globules, provided they are approximately uniform. Even the smallest of these globules is extremely large when compared with the oil molecule, and the act of burning takes an appreciable time; it must also be remembered that these globules are many diameters apart, and the air between them does not get much opportunity to become consumed; so an excess of air must be supplied.

There are new burners on the market which operate on the principle of vaporizing the oil, that is, reducing it to the molecular state, which allows perfect mixing so that the air supply can be cut down to the minimum amount with a corresponding increase in efficiency. The furnace itself must be adapted to the burner that will be used, and should be just large enough so that all the oil is completely burned before the gases leave the furnace. Many oil furnaces are operating with flames shooting out from two to six feet, which simply means that they are inefficient and are burning a large percentage of the oil supply outside the furnace where it is wasted. On a well designed and correctly operated furnace the escaping flames are about six inches high and without any blast action. Combustion should be almost complete before the gases reach the stock which is being heated. There are two advantages to this: first, the maximum heat is delivered to the stock; and second, since the oxygen is practically exhausted, there is no tendency to scale the stock. The furnace walls must be well insulated to prevent radiation and conduction losses, and also to actually increase the temperature in the furnace. Openings must be kept to a minimum in area for the same reason. An efficient furnace should be able to heat a 1¼-inch diameter mild steel bar from room temperature so rapidly that in three minutes the first drop of molten steel will fall from it.

Medium sized furnaces, say those heating stock weighing between five pounds and one hundred pounds, should be designed so that they will heat the stock as fast as it can be handled, and thus eliminate loss of time through the workmen waiting for the furnace to heat the stock. The error must not be made of making the furnace any larger than is consistent with proper combustion, good heat insulation and capacity for the required amount of stock. This design when properly operated will heat the stock with the least possible consumption of fuel, which is not only economical, but greatly increases the comfort of the men who have to work near it as well. With proper combustion, the presence of obnoxious and poisonous gases is practically eliminated, and if the shop is high, the use of chimneys can be avoided.

Any saving in oil that might be obtained from slow heating sinks into insignificance if the men and machinery have to wait, because the men's time and the overhead and fixed charges are much greater than the value of the oil, and, furthermore, slower output per furnace means more men, furnaces, equipment and buildings. As forging machines, in general, are very quick-acting and can easily perform their cycle of operations in less time than the piece of stock can be heated, it is obvious that the utmost economy under these conditions can only be obtained by heating the stock at its maximum rate, which is to get the interior hot enough before the exterior surface starts to melt or gets to a temperature high enough to spoil the stock for its particular work. It is doubtful if a practical furnace has ever been built which would heat stock at this rate. From the above considerations, it is apparent that, in general, the most important factor in over-all economy is the rapidity of heating, and no fear need at present be felt of reaching the limit.

The stock is heated, of course, because the temperature of the furnace is higher than that of the stock, and as soon as it reaches the temperature of the furnace it is no longer being heated. This is obvious, but to keep the furnace at the temperature to which it is desired to heat the stock is very inefficient, however desirable it may seem from the standpoint of avoiding burnt stock. Maximum economy, which also means maximum output, can only be obtained by keeping the furnace temperature as high as possible, and it must be noted that the difference in temperatures is constantly being reduced as the temperature of the stock increases, that is, the rate of heating decreases as the temperature of the stock increases.

To find the relative effects of various furnace temperatures on the rate of heating stock, a series of experiments was made with the following results:

RELATIVE HEATING TIME OF STOCK FOR VARIOUS FURNACE AND STOCK TEMPERATURES

| Temperature of Furnace, Degrees F. | Stock Temperatures, Degrees F. | | | | | |
|---|---|---|---|---|---|---|
| | 500 | 700 | 900 | 1100 | 1300 | 1400 |
| 1600 | 2.20 | 3.40 | 4.75 | 6.45 | 8.50 | 9.75 |
| 2000 | 0.75 | 1.20 | 1.60 | 2.20 | 2.90 | 3.45 |
| 2500 | 0.50 | 0.75 | 1.15 | 1.45 | 1.90 | 2.15 |
| 2700 | 0.30 | 0.45 | 0.65 | 0.75 | 1.00 | 1.15 |

*Machinery*

Eliminating the 1600-degree furnace, because it is not probable that such low temperatures will occur in practice, and taking the relative heating rate for unit time for the other three furnaces, the results are as follows:

| Temperature of Furnace, Degrees F. | Average Relative Heating Rate |
|---|---|
| 2000 | 1.00 (Taken as unity) |
| 2500 | 1.80 |
| 2700 | 2.74 |

Thus it is seen that while the 2000-degree furnace is heating 100 pieces, the 2500-degree furnace will heat 180 pieces, and the 2700-degree furnace will heat 274 pieces. An increase of only 700 degrees F. has increased the furnace output 174 per cent. It is very apparent that the rate of heating varies much more rapidly than the difference in temperature, and a practical rule has been deduced from the tests as follows:

| Temperature of Furnace, Degrees F. | Average Relative Heating Rate | Ratio of Third Power of Temperature |
|---|---|---|
| 2000 | 1.00 | 1.00 |
| 2500 | 1.80 | 1.95 |
| 2700 | 2.74 | 2.45 |

As the third power ratio and the relative heating rate so nearly coincide, our practical rule is: "The relative heating rate varies as the third power of the actual temperature for furnaces used to heat stock for forging purposes." This, of course, applies only to furnaces used for heating stock to the same temperatures. A comparison between a welding and

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bending furnace by this rule would probably give erroneous figures; in fact, the bending furnace would probably be unable to give a welding temperature at all, but the effect of an increase in temperature of the welding furnace on its output could be solved by the above rule, and the same applies to the bending furnace.

As the obtaining of high temperatures is of such great value, it is well to investigate what the factors are that determine this condition, and as we already have discussed high insulation, minimum radiation and conduction, minimum air supply and efficient burners, the only thing left is the actual composition and heat value of the oil itself. The composition of oils as used for furnace work does not vary greatly, although their heating value does. As an instance of this, the petroleum of West Virginia is 83.5 per cent carbon, 13.3 per cent hydrogen, and has a heating value of 18,324 B.T.U., while the oil known as "Mineral Seal" has 83.3 per cent carbon and 13.2 per cent hydrogen, and yet gives 20,065 B.T.U.; also the oil known as "Petrolea" has 84.4 per cent carbon, 13.4 per cent hydrogen, and gives 20,410 B.T.U. The ultimate analysis of any oil does not give more than a general indication of its heating value. The reason for this is because the energy of disassociation, which is not very well known, varies for different oils; and the condition of the oxygen, whether combined with the hydrogen or not, the amount of ash, moisture, etc., are all variables. The actual B.T.U. content is the most direct indication of the oil value. The B.T.U. value and the approximate analysis of any oil being known, it is a simple matter to calculate the flame temperature $T$ as follows:

$$T = \frac{\text{B.T.U.} - H - h}{S}$$

where $H$ = heat converted into work by expansion of gases of combustion;

$h$ = heat absorbed by steam produced;

$S$ = mean specific heat of products of combustion.

Applying this formula to five oils of different B.T.U. contents, the following temperatures are derived:

| B.T.U. Value of Oil | Approximate Temperatures of Combustion, Degrees F. |
|---|---|
| 16,000 | 2952 |
| 17,000 | 3142 |
| 18,000 | 3332 |
| 19,000 | 3522 |
| 20,000 | 3712 |

It is apparent that the B.T.U. value has a great influence on the temperatures that can be obtained in the furnace. Moisture affects the flame temperature in two ways: first, by reducing the available B.T.U. value by the amount absorbed in the form of latent heat, which is very high, being about 1000 B.T.U. per pound of water or moisture; second, by its high specific heat when in the form of superheated steam. In the formula, the effect is apparent, by the subtraction of the latent heat from the B.T.U. and the division by the specific heat times the amount of moisture present. Oil should, therefore, be given ample time to settle as much of the contained water as possible, and full credit should also be obtained for it from the oil supply company.

From the preceding table it is seen that the B.T.U. value has a more important effect on the flame temperature than might at first be assumed. It is now necessary to find what effect this has upon the relative heating values when used in metallurgical furnaces. The rule connecting heating values with temperature has been obtained, so by applying this rule to the temperatures obtained, it is a simple calculation to get the relative heating values. First, some particular heating value must be chosen as unity, and as an oil of 17,000 B.T.U. value is in extensive use for this purpose, it will be taken to represent unity. On this basis the following table gives relative heating values:

| B.T.U. Value of Oil | Relative Heating Value |
|---|---|
| 16,000 | 0.83 |
| 17,000 | 1.00 |
| 18,000 | 1.19 |
| 19,000 | 1.40 |
| 20,000 | 1.66 |

Thus it is seen that while 17,000 B. T. U. oil is heating 100 pieces, 19,000 oil will heat 140 pieces. As the ultimate economy should be expressed on an actual cost basis, the equivalent value of the various oils will now be taken up. This relative value of oils will vary somewhat for each specific case, as the saving due to quicker heating is more than proportional to the extra stock heated by the same amount of oil, for there is more stock heated in the same time; thus the same amount of labor and equipment will have greater production, and the value of this will necessarily depend upon the particular work being done. It will be a conservative estimate to simply estimate the value of the oil upon its relative heating value, and taking 17,000 B.T.U. oil at $1.50 per barrel as unity, the following table gives the various values of the other oils per barrel:

| B.T.U. Value of Oil | Relative Value per Barrel |
|---|---|
| 16,000 | $1.24 |
| 17,000 | 1.50 |
| 18,000 | 1.78 |
| 19,000 | 2.10 |
| 20,000 | 2.46 |

It is important to note that a high flame temperature cannot be obtained by any haphazard methods. The oil must be completely burned without smoke in approximately the theoretical amount of air and in correctly designed furnaces. If this is not thoroughly done or excess air is used, then the saving due to the increased B.T.U. value may easily be lost, as a very little excess air will quickly eliminate the increase in temperature and increased rate of heating due to the richer oil.

* * *

## FARM TRACTORS

The present high cost of living, due in part to scarcity of farm products, has brought squarely before the American people agricultural conditions and the problem of producing food more cheaply. The farmer has gradually been growing poorer and poorer because the returns for his labor were inadequate for decent support. The rising costs of farm labor and the scarcity of laborers are acute difficulties. Thousands of acres of tillable soil in the East have been abandoned and the former occupants have gone to the towns and cities where they can earn a living easier. The abandonment of the farms, increased population and inefficient means of distribution, together with the demands of the millions in Europe for food, have raised prices to unprecedented heights. Farm tractors are being developed in a variety of forms and are regarded by their optimistic promoters as a partial solution of the farmer's problem. What the ultimate form of the farm tractor will be is not yet clear.

There is a great variety of styles, each of which apparently has certain advantages. One make that can be operated by one man the same as a team has the power of six horses, and may be used for doing all kinds of farm work. The turning radius is so short that the tractor can make a complete turn in a ten-foot circle. The fuel used is No. 1 engine distillate. Advantages claimed for the farm tractor are that it eats nothing when not working, and that it can be used not only as a tractor but for generating stationary power, driving grinding machinery, threshing machines and other machinery on the farm. The farm tractor is not subject to disease; it can be operated from early dawn until late at night, day after day, without fatigue. Some of the successful farm tractors are built on the caterpillar principle, being supported on endless belts or chains that give a large area of contact to support the load on soft ground and provide for traction.

* * *

Gasoline readily vaporizes when exposed to the air of any temperature down to 15 degrees F. below zero. The vapor is nearly three times as heavy as air, and when mixed with the proper quantity of air becomes violently explosive. If confined where there is poor ventilation, this mixture will sometimes remain in the explosive condition for several months. The vapor will ignite from an open flame, a spark from an emery wheel, a sufficiently heated surface, and even from a spark of static electricity from the human body.

# LETTERS ON PRACTICAL SUBJECTS

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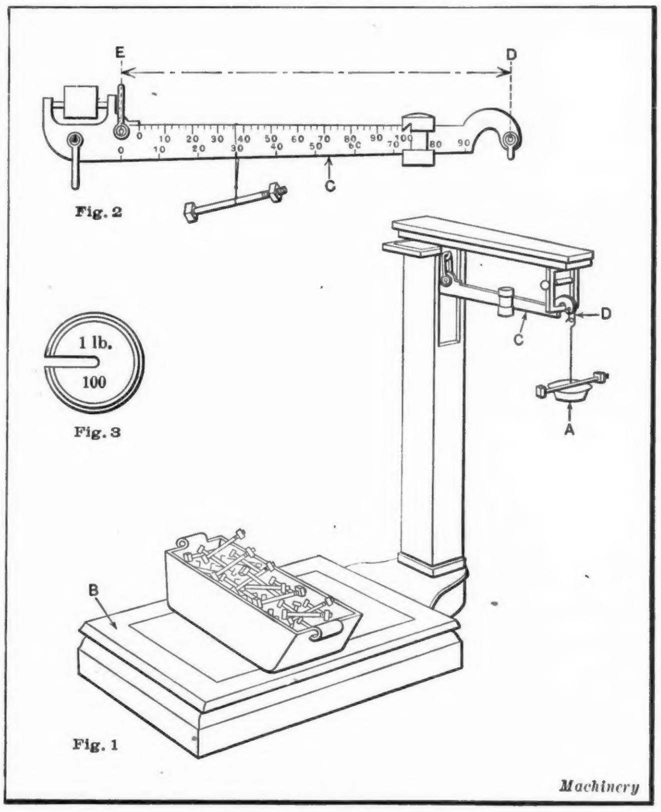
## A COUNTING SCALE

There is always a definite ratio between the weights which hang on the tip of a scale beam and the load on the platform. On a scale of the type shown in Fig. 1, this ratio is usually 1 to 100; that is, one pound on the counterpoise *A* will balance one hundred pounds on the platform *B*. By taking advantage of this relation, it is possible to count with accuracy drop-forgings or the product of automatic machines, nuts, bolts, etc. Since they are practically of uniform weight, one piece laid on the counterpoise will balance one hundred similar pieces on the platform; ten pieces will balance one thousand, etc.

To ascertain quantities less than one hundred, it will be necessary to do a little work on the scale beam *C*, shown in Fig. 2. If one piece hung from the tip pivot *D* balances one hundred, it will balance only one-half as many when hung half way between the pivots *D* and *E*, or one-hundredth as many at one-hundredth the distance. So the distance from *D* to *E* should be divided into one hundred equal parts, and




Figs. 1 to 3. Counting Pieces on a Scale

the lines separating these parts marked with a scriber on the lower edge of the beam. It may be easier to divide the whole into ten parts and each of these into ten parts. No attention should be paid to the graduations already on the beam.

To count an unknown quantity of pieces, balance the empty box by moving the poise, which in this case has no other use. Fill the box with the pieces and put one on the counterpoise *A*; if this does not balance, add others on counterpoise *A*. When the last one put on is seen to be too much, take it off and, by means of a fine thread looped over the beam, as shown in Fig. 2, move the piece along the scale beam until a balance is obtained. Note the mark on the lower edge of the beam at this point. If there are seven pieces on the counterpoise, and the one on the scale stops at 30, there are 730 pieces in the box. It is not necessary to graduate the beam into one hundred parts. If ten equal spaces are made, the pieces can be balanced to the nearest ten and the few remaining can be counted by hand. If the pieces weigh less than 1/4 pound each, they should be counted on a smaller and more sensitive scale, since the one illustrated is not adapted for fine work. The ratio between the counterpoise and the platform is indicated on the weights, as shown in Fig. 3. It may not always be 1 to 100, but it will always be a fixed factor.

Rutland, Vt. W. H. SARGENT

## REMOVING BROKEN TAPS AND SCREWS FROM BRASS PARTS

A jobbing shop, eager for work to carry it through a dull season, took a large contract at a figure that would yield a small profit if no unforeseen difficulties were encountered—and then the difficulty appeared. One of the last operations on a brass part was the tapping of a blind hole. Whenever the No. 4-40 bottoming tap broke off too short to be extracted by ordinary means, as it did with discouraging frequency, there was nothing to do but to scrap the part, on which some two dollars' worth of lathe, miller, and drill-press work had been expended. The jigs were furnished by the customer and no change in the order of operations was possible. As the size of tap-drill was specified on the blueprint and the customer refused to permit the use of a larger drill, the shop owner could only gaze sadly at the growing scrap heap which threatened to absorb all his anticipated profits.

Misfortunes, we are told, seldom come singly, and when the pile of spoiled parts had grown until its cost exceeded $200, the second bit of ill-luck arrived. The "boss" dropped his cherished watch on the floor and on opening the back of the case he saw lying loose the heads of the two steel screws which are tapped into the pillars to hold the barrel bridge in place. Trying the heads with a file, he found them hard and foresaw an expensive repair job that would further deplete his shrinking "roll."

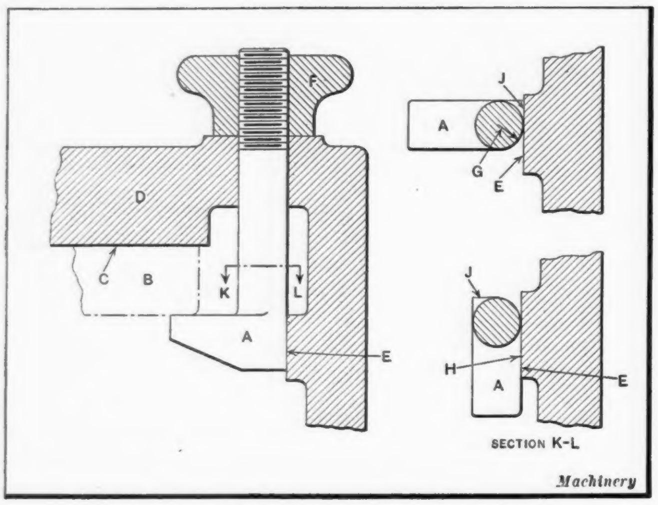
When the watch was returned and he was told that all that had been necessary was to remove the broken screws and substitute new ones, he asked the watch repairer to reveal the method of extraction. As soon as he acquired this "secret," he returned to the shop and made, in an enamel-lined kettle, a fairly strong hot solution of ordinary alum. Then placing his brass parts therein, in a few minutes he was able to loosen the fragments of taps so that they were easily removed.

It sometimes happens, especially in clock repairing, that a broken screw must be removed from a brass part which has other steel members riveted to it. In this case, as it would be difficult and expensive to take off and replace the riveted parts, another method is employed. All but the seat of operations receives a protective coat of vaseline, then very dilute cold sulphuric acid (twenty or thirty drops to a pint of water) is put upon the screw. This acts slowly, and has to be replaced by fresh acid as it becomes exhausted, but in time will do the work. Great care, of course, must be taken to remove all acid when the job is completed, the usual plan being to neutralize it with ammonia and then rinse thoroughly with hot water.

New London, N. H. GUY H. GARDNER

## SELF-LOCATING HOOK BOLT

The October number of MACHINERY contained the description of an improved hook bolt, the advantage of which was a support at the back. The writer considers the design described rather expensive, and submits an alternative arrangement, as shown in the accompanying illustration. This hook




Self-locating Hook Bolt with Support at Back of Head

bolt is simple, inexpensive, can be supported at the back of the clamping point, and is self-locating.

In the illustration, *A* is a hook bolt used to clamp the work *B* against the locating pad *C* in the jig *D*. The back of the hook bolt is seated against a finished pad on the jig *E*, thus providing ample support at its weak point. *F* is a handwheel that is threaded to receive the end of the hook bolt; a nut may be used in place of the wheel, if preferred. By turning the handwheel *F*, the clamp is released, the hook bolt turning on the radius *G* until the face of the bolt rests on the face of the pad, as shown at *H*. To clamp the work *B*, all that is necessary is to turn the handwheel and the hook bolt rides again on the radius *G*, until the face *J* seats on the pad *E*. Thus the hook bolt is self-locating and it is unnecessary for the operator to look into the jig to see if the hook bolt is in the proper position for clamping and hold it while it is being tightened. This hook bolt can be used in a closed box jig and provides the necessary support back of the head, which makes it a useful and inexpensive clamping device.

New York City THOMAS ORCHARD

## ECCENTRIC BUSHINGS

In laying out drill jigs it is often necessary to provide for two holes that are very close together. On simple drilling, when fixed bushings only are used, this is easily done by the use of reducing bushings, as shown in Fig. 1; but for reamed holes which have to be so accurate that the "spot, drill, and ream" operations cannot be performed, eccentric bushings have to be used. For two reamed holes of different sizes, four eccentric bushings must be provided. The form of these bushings is shown in Fig. 3 and their proportions and disposition in Fig. 4. Every toolmaker knows how difficult and expensive the making of eccentric bushings is for the ordinary tool-room.

A case came to the writer the other day where a 0.127-inch reamed hole and a 0.5-inch hole 0.344 inch distant, as shown in Fig. 2, were to be drilled and reamed at the same setting in the jig. This was done by using only one eccentric bushing, made of soft crucible steel, of the form shown in Fig. 5. A locating block *A*, Fig. 6, was used to give the proper alignment to this bushing, and another locating block *B* was set on top of *A* to locate the bushings shown in Fig. 7 so that it would be impossible for the operator to put the eccentric bushing in the wrong position and transpose the holes. As the bushings are concentric, the locating block *B* and the bushings can be fitted freely at their contact, thus facilitating changes by the operator.

Montreal, Canada J. G. BLANCHET

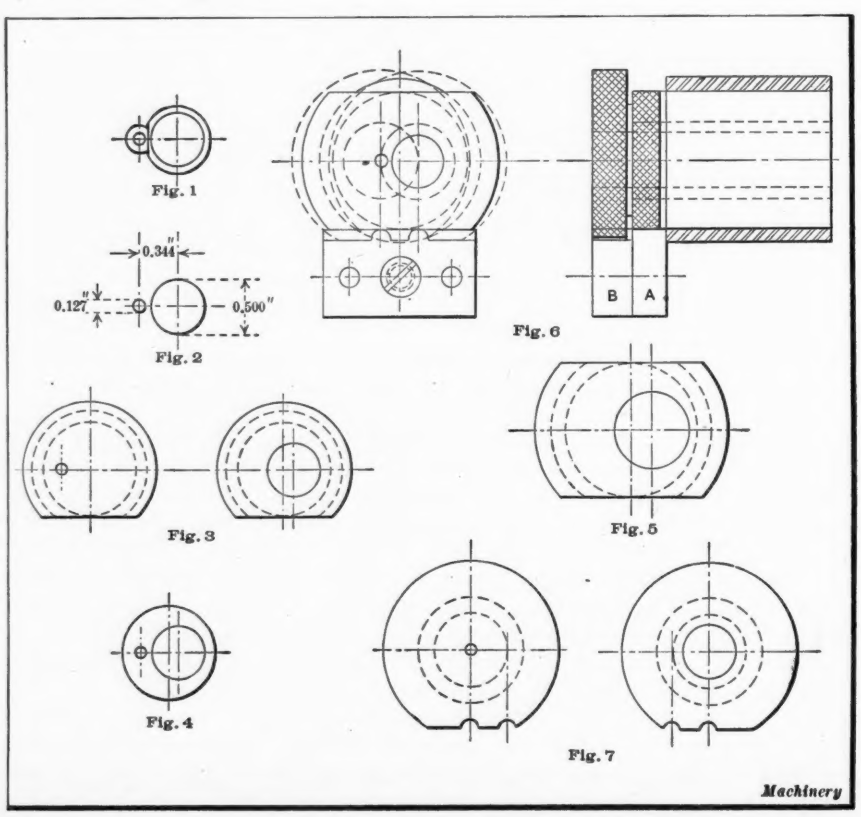
## BONUS SYSTEM FOR SMALL SHOP

An interesting and successful bonus plan for shop employes has recently been developed at the plant of the Guerber Engineering Co., Bethlehem, Pa., which specializes in general machine work as well as in the production of structural steel shapes and railway track material. The shops employ an average of about 160 men in the different departments of operation, exclusive of office force, engineers, or outside iron erectors.

This bonus system is the result of extensive investigation in the past few months, brought about through the continual difficulty of operating the shops at maximum capacity. It was found that for the first ten months of the past year only about one-third of the force, or an aggregate of fifty shop employes, had worked at full time during many of the months, naturally reducing the efficiency of the plant. While this might be attributed, in a way, to the prevailing shortage of experienced and efficient workmen, it was shown to the satisfaction of officials of the company that the primary cause was the fact that employes would not work regularly and consistently, owing to the increased wage scale which has been placed in effect generally in the past two years and the consequent added surplus to the earnings of the men. Thus it was deemed advisable to devise a system of bonus payments for regular attendance at work, and the results attending the introduction of the plan attest its effectiveness.

The bonus is based upon a certain percentage of the employe's wages for each month and is paid to all workmen who engage at full time on the regular working days during the respective month. This percentage is placed at a minimum of 5 per cent of the wages if fifty or less employes work full time during the month; for each additional ten, or fraction of ten, employes who so engage during the month, the rate is increased by 1 per cent, until a maximum of 16 per cent is reached in the event of the regular attendance of practically the entire force—between 151 and 160 men—in the particular month.

In addition to the men entitled to the bonus payment for regular daily attendance during the month, all employes who work full time except for one turn, or part of one turn, are given a bonus of one-half of that earned by the workmen who have a perfect record. However, the number of employes who may have missed one turn, or day, is not added to the num-




Figs. 1 to 7. Bushings for drilling Two Holes Close together

ber of men who have worked at full time, in the determination of the bonus; the rate of bonus is entirely dependent on and governed by the maximum number of full-time workers for the particular month; the greater the number of men who work regularly, the larger is the bonus for each employe.

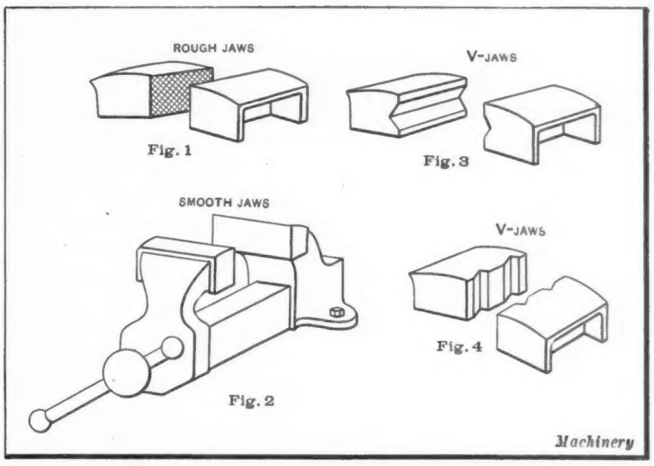
It is interesting to note that during the first two months of operation, November and December, 1916, noticeable results have been attained through the inauguration of this novel bonus plan. Approximately twice the maximum number of men were engaged at full time against the total of any previous month of the year; the record for November was slightly better than that of the following month, owing to the holiday season. In November, all departments of the plant established new records for monthly production.

Newark, N. J. L. R. W. ALLISON

## SPECIAL VISE JAWS

An improvement that the writer thinks would add greatly to the usefulness of the ordinary vise and at the same time save labor, would be to provide for each size of vise false jaws of various designs. For heavy work, when a rough face with a good grip is necessary, the vise should have heavy coarse-cut jaws, Fig. 1, that would hold the work without any possibility of its slipping or turning. For fine or polished work, the jaws should have a perfectly smooth face, Fig. 2, that would not mark or mar the work. For round work, the vise should have V-shaped jaws. To hold work in a perpendicular position, the vees should be arranged as shown in Fig. 4, but to hold work in a horizontal position the jaws shown in Fig. 3 should be used. Anyone who has tried to hold round work in the ordinary vise will appreciate the usefulness of these V-shaped jaws. It is almost impossible to clamp round stock tight enough to keep it from turning; the writer broke three vises, at different times, trying to get the vise to hold the work. By having two or three sizes of vees in each pair of jaws to take different sizes of round work, less pressure would have to be exerted to obtain a firm grip on the work, thereby reducing the stress and lessening the chances of the vise breaking.

The false jaws could be made and kept in stock by the vise manufacturer, and could be ordered separately or in a complete set, as the occasion required. They should be of a simple design that could be easily and quickly applied without the use of set-screws or nuts. No man who has but a few pieces of work to do cares to spend time looking for a screw-driver or a special wrench to secure the jaws in position; they should fit the vise snugly and yet slip on and off like an old coat.



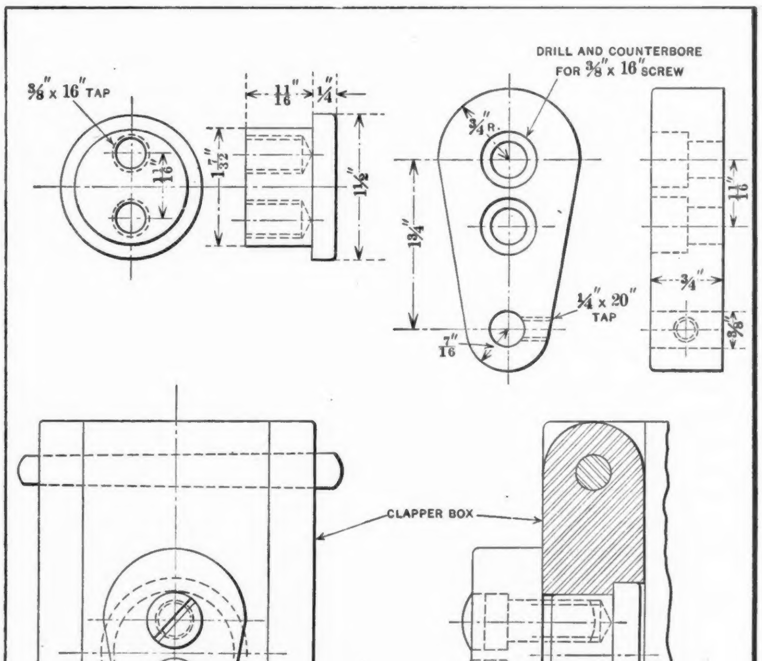

Figs. 1 to 4. Suggested Forms of Vise Jaws

Plainville, Conn. HARRY B. STILLMAN

## SPLINING TOOL FOR SHAPER

The writer has designed a splining tool for a shaper that has proved very satisfactory for shaping out dies, keyways, etc.; this tool is shown in the accompanying illustration. Its advantage is that it does away with the toolpost. When the old-style tool is used the tool must be let down so far, in order to give clearance to the toolpost, that a large job cannot be done efficiently because of the tendency of the tool to chatter and to dig into the work. But with this design the tool is simply made long enough to go through the piece to be shaped, and, being rigidly held, it will not chatter. In the illustration, the dimensions are given for the stud that fits in back where the toolpost is located, but this should always be fitted to the machine on which it is to be used.

Bridgeport, Conn. GUSTAVE BAHR




Splining Tool for Use in Shaper

## PREVENTING NUTS JARRING LOOSE

Not long ago some of the nuts on a small grinding machine were continually jarring loose because of vibration. An investigation showed that both bolts and nuts were made of cold-rolled steel, and were soft; they also fitted loosely. To remedy this trouble, some bolts were turned up in the lathe, and the threads were made a tight fit in the nuts. The latter were then casehardened and screwed onto the bolts with a six-inch wrench. They have caused no trouble since. By using soft bolts and hardened nuts, and having a tight fit, the nuts are given a chance to "freeze" to the bolts, making a tight and permanent connection. This freezing cannot take place, as a rule, where both the bolt and the nut are soft; nor where both are hardened. A very tight fit is not required.

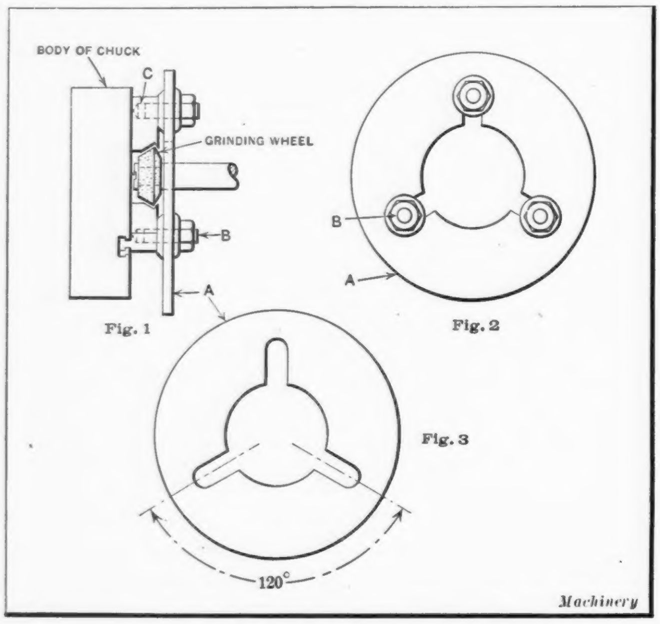
Plainfield, N. J. J. B. MURPHY

## TRUING SCROLL CHUCK JAWS

In connection with the devices for grinding chuck jaws true, described in the October number of MACHINERY, the writer would say that the device shown in the accompanying illustration has given satisfaction for some time. It is used in a shop that is turning and boring bevel gears, with cast teeth, on a Hartford automatic screw machine equipped with an automatic scroll chuck. At first, a ring with three ad-

justing screws was used to hold the jaws rigid, but this had to be set so far back in the chuck, to clear the grinding wheel, that the looseness in the chuck jaws caused the gears to run out, sometimes necessitating three or four trials before the jaws were set true. So it was decided to make a machine-steel ring *A* with elongated slots for adjustable studs *B*. A hole *C* was drilled in each jaw to take the studs.

The operation is as follows: The jaws are closed on the gear by hand and the plate is placed on the jaws with the studs in the holes. The nuts are then tightened and the relative positions of the studs and jaws are noted. The plate is then lifted off, the jaws opened, and the gear removed, after which the jaws are closed until the studs enter the holes in the same relative positions as before, and the chuck is tightened by hand. See Fig. 1. The slight play in the stud holes allows the jaws to close farther than when the gear is in position, thus allowing the grinding wheel to remove sufficient stock to true the jaws and maintain the correct radius. The pressure, being exerted on the extreme end of the jaws, places them practically in the same position as when working,




Figs. 1 to 3. Device for truing Scroll Chuck Jaws

thus securing a true grinding. Figs. 2 and 3 show the plate with and without studs. These plates are made in three sizes.

Woonsocket, R. I. HARRY BROOK

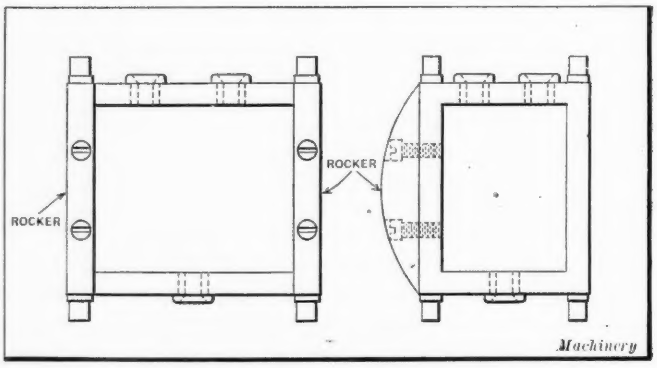
## SHARP-POINT CENTER PUNCH

For accurate drilling it is generally the practice to begin with a small drill near the size of the web of the larger drill. On this principle, the writer always grinds the center punch to a more acute point than it ordinarily has—always about 30 degrees. This makes a deep impression and the small drill will follow in the center, provided the burr raised by the center punch is hammered down to compress the metal. The bottom of the center-punch mark will be visible until the drill is well started, so that it is possible to see how near the drill is to the center, without scribing a circle with the dividers. The point of the center punch will not break off if the tool is turned slightly by the fingers during the center-punching operation.

Akron, Ohio E. J. HIGGINS

## A LABOR-SAVING JIG

The box drill jig shown in the accompanying illustration was used for drilling three holes in a certain piece that was to be produced in quantity. The jig is made from a forging, two stationary bushings being inserted in the top and one in the bottom. As the jig and work weighed about twelve pounds, it was hard for the workmen to be constantly lifting the jig and turning it over for the operation on the other side. So two pieces of steel were machined to a radius and attached




Drill Jig provided with Rocker to facilitate reversing its Position

to the jig between the four feet on the side opposite the leaf. With the aid of these rockers, the jig is now easily turned over from one side to the other. They do not interfere in any way with the working parts, and when changing work, the jig is supported by the rockers.

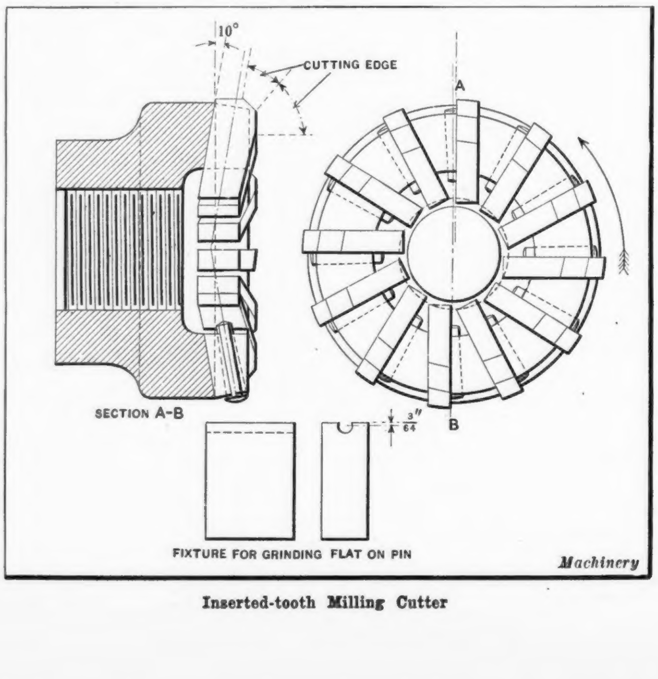
In this way, the jig is always on the drilling table, and there is no likelihood of the operator letting it fall to the ground or banging it down with a tired arm and snapping the bushing or legs, which are hardened to glass hardness. In addition, the operator does not have to work so hard and the production is considerably increased.

New Haven, Conn. ERIC LEE

## INSERTED-TOOTH MILLING CUTTER

The inserted-tooth cutter shown in the accompanying illustration is one that was recently made to replace a solid high-speed butt mill. The nature of the work is such that it requires a small cutter about 3½ inches in diameter.

The holder shown contains twelve teeth of No. 2 stellite, this being the best grade for milling cast iron when the chip is light and a good deal of scale must be removed, which were the conditions in this case. The solid mills had twenty teeth, but twelve is all that is practical in this inserted-tooth holder. However, this mill cuts just as well as the other, as the stellite cutters can be run about 50 per cent faster and, with only a slight increase in feed, the same chip per tooth will be produced. The chief feature of the holder is that when the cutters become ground down until there is no room for chips, the taper pins can be driven out and the cutters reset. In the case of the solid mills, it was necessary to anneal, cut over, and harden them. The cutters of this mill, as shown, have two cutting edges, one on the 45-degree bevel and the other on the face, which need be only a little longer than the feed per revolution of the mill. The cutters are set in on an angle of 10 degrees to the face, so that when they are driven out to be reground, there is room for grinding on the face as well as the bevel. The No. 4 taper pin that holds the cutter in




Inserted-tooth Milling Cutter

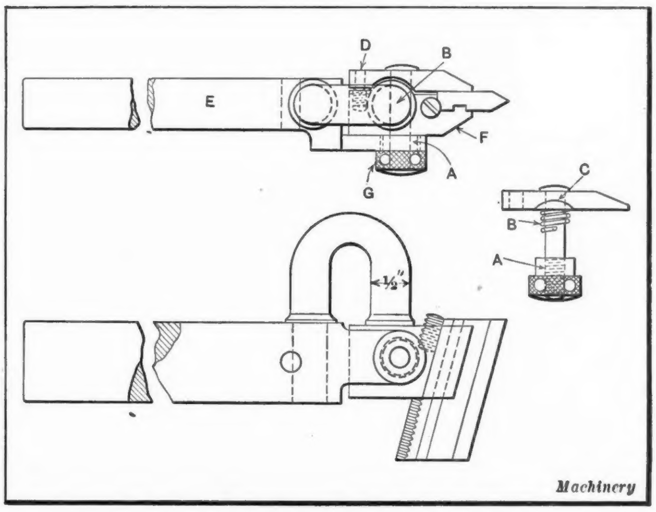
place is ground flat on one side, the same amount of stock being taken off the entire length of the pin. This is accomplished by making a fixture as shown in the illustration, which needs no explanation. The taper holes for the pins, which are, of course, drilled and reamed before the slots are cut, are drilled on the dividing head, so that they are accurately spaced and pitched at the same angle to the cutter slot as the side of the taper pin is to the cutter. This insures that the pins will bear their full length. It will be noticed that the thrust on the cutters, when in use, tends to drive them back, thus drawing in the pins and tightening their hold.

The body of the holder is made of a good grade of cast iron, as the compressive strength is much greater than that of steel and it retains its shape better. It was later found that cutters from large inserted-tooth mills of standard make could not be used after they had become less than 1¼ inch in length, as the slots for the cutters are 1¼ inch long and it is not good practice to use a cutter shorter than the slot. So these cutters were used in the smaller holders, thus saving the cost of new high-speed cutters.

New Britain, Conn. E. M. BIDWELL

## SPRING THREADING TOOL

The accompanying illustration shows a spring threading tool that the writer designed and has used successfully on screw gages and taps for a year and a half. The tool-holder *F* and




Spring Threading Tool

spring are one piece and made of carbon tool steel, spring tempered. The body of the tool *E* is made of carbonized cold-rolled steel and has a projection that forms a support on one side of tool-holder *F*; this keeps the tool-holder from making a staggered thread. A hole is drilled through this projection 1/64 inch larger than washer *A*, which gives tool-holder *F* a free chance to spring. Washer *A* is made of hardened tool steel, and is 0.0015 inch longer than tool body *E* is thick. Tightening nut *G* clamps on washer *A*, and tightens the blade in the holder *F*. The small coil spring *B* holds the nut against the washer *A* and keeps out chips while the blade is being removed. *D* is an adjustable screw for the blade clamp.

Kenosha, Wis. F. S. RIPLEY

## PIERCING AND DRAWING GANG DIE

An interesting gang die was used to make the piece shown half size in Fig. 1. As shown at a greatly reduced scale in Fig. 3, the dies are made, like a half sub-press die, by using a cast-iron die-block *B* and a punch-holder *C* fitted with two hardened and ground guide pins *D*. The die *E* is made from a piece of special tool steel 1¼ by 5 by 11 inches, which was planed all over, after which the holes for the different operations were roughed out. The piece was then carefully annealed to relieve any strains that might be in the steel. It was then finished to size, hardened at 1450 degrees F., and drawn in oil to 450 degrees F., when it showed a variation of 0.003 inch. The edges of hole *F* are rounded considerably to facilitate drawing down the piece; a spring pad is used.

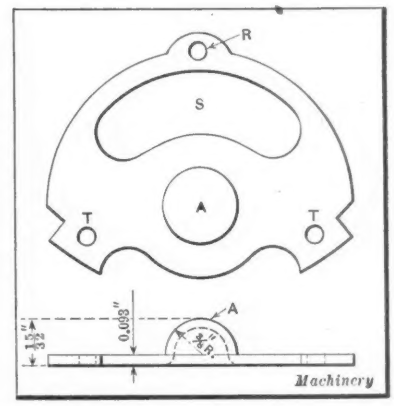



Fig. 1. Piece made in Gang Die

The part *H* is a piece of tool steel, worked out to the finished size of the boss, that has been hardened and fastened into the cast-iron die-block *B*, as shown in Fig. 2. The opening *I*, Fig. 3, in the die is fitted with a pad controlled by a heavy spring and suitable plates fastened to die-block *B*. In the ends of punches *J* and *M* are recesses in which the part that forms the boss is inserted. In this way, when the punch is to be ground down, the part forming the boss can be removed and afterward inserted. Punch *M* is 3/8 inch shorter than the cutting punch *J*, the piercing punches *L* are 3/16 inch shorter than punch *J*, and the slotting punch *K* is 1/8 inch shorter than punch *J* and has a shear of about 3/32 inch, as shown. A 5/8-inch spring stripper, held in position by shoulder screws, is used to hold the stock and strip it from the punches.

The dies were used in a No. 65 Consolidated geared press running at forty strokes a minute. As a finished piece was turned out at each stroke of the press, from 12,000 to 15,000 pieces were made in a day. The piece shown in Fig. 1 was made from hot-rolled strip steel 0.093 by 2.75 by 75.5 inches. In operation, the strips, which are long enough to make twenty blanks, are fed up against the gage marked "First Stop" in Fig. 3, and the press is tripped. A hole *R*, Fig. 1, is then punched in the strip and the boss *A* is drawn up by punch *M*. Owing to the tendency of the metal to crack across the boss *A* when the piece is made in one operation, this part is drawn up 1/16 inch larger than the finished size and with round corners, and later squeezed down to the desired size. As only the outside of the boss is used it is necessary to make the shape of this part a little full in order to get as true a radius as possible and also to make the metal fill the die.

The strip is then moved forward until the hole *R* fits over the gage pin marked "Second Stop," and the boss drops into the clearance hole *G*. When the press is again tripped, the slot *S* and holes *T*, Fig. 1, are formed by the punches *K* and *L*, respectively. The strip is then pushed forward over the blanking die *I* where pilot pins in the punch (not shown) engage the holes, centering the blank. Punch *J* then cuts out the blank and travels down and finishes the boss in die *H*, which is set solid in the cast-iron bolster. On the up stroke of the press, the blank is forced up by the pad in die *I*, which is controlled by a spring bumper fastened to the bottom of the die. This pad, working in conjunction with the spring stripper, forces the blank back into the strip of steel and it is carried out over the die when the stock is fed forward for the next blank. No stripper is necessary to remove the blank from the forming punch *J* because this punch is made slightly tapered at the large part of the ball. A plunger acting with the arm

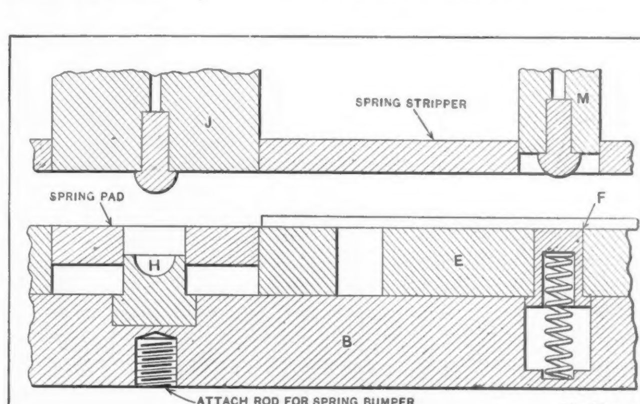



Fig. 2. Cross-section through Roughing and Finishing Dies

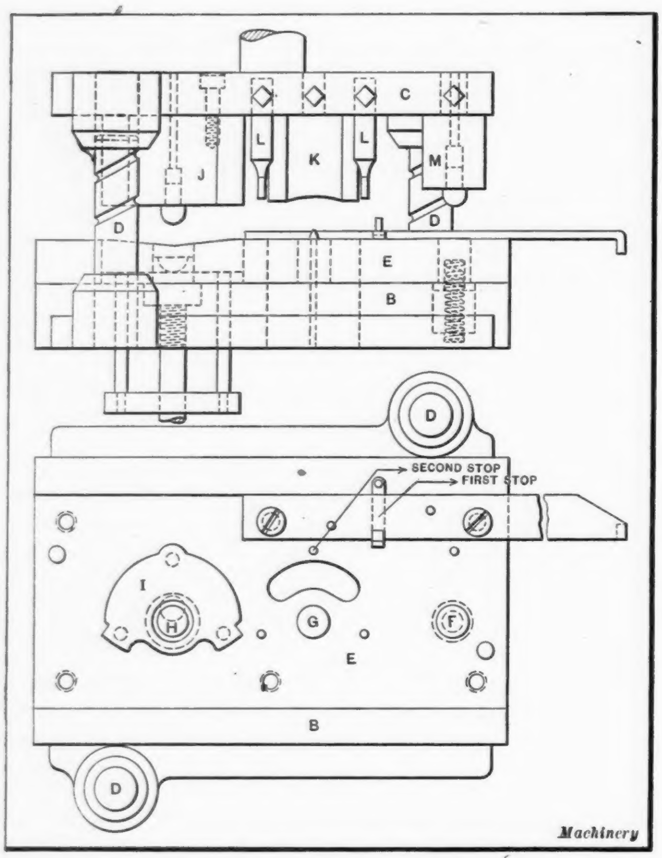



Fig. 3. Punch and Die for making Piece shown in Fig. 1

of the press knocks the blank out of the strip into a chute. All parts of this die must be accurately made or the stock will crawl, which would, of course, result in producing an unsatisfactory job.

Chicago, Ill. A. H. WILSON

## BUILT-UP SNAP GAGES

In the October number of MACHINERY a type of built-up snap gage was described that is very well thought out but is possibly capable of improvement. The method of grinding the tolerance in the upper jaw necessitates two grinding operations when repairing after continued use. In the gage shown in Fig. 2, the tolerance is ground once only in the central piece and the jaws are ground parallel. This makes it possible to repair the gage by simply removing the jaws and grinding them true on a surface grinder; when reassembled, the gage is in condition to be used, as before. By the use of the chart shown in Fig. 1, it is possible to determine the proportions of gages that are not given in the table. This chart is self-explanatory and is simply plotted from the largest and smallest gages required and reading to the nearest fraction. This system of plotting is especially advantageous when standardizing a line of tools, as it is only necessary to plot the mean and the extreme tools in order to obtain a fairly accurate ratio for the intermediate sizes.

LESLIE A. WELLS

This type of gage was mentioned in the article referred to but was not illustrated.—EDITOR.

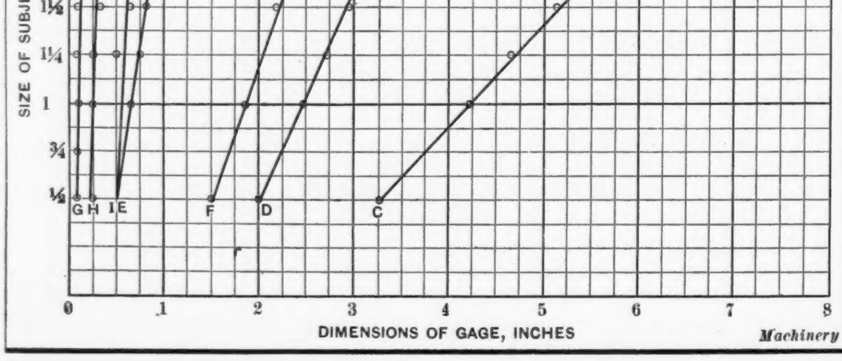
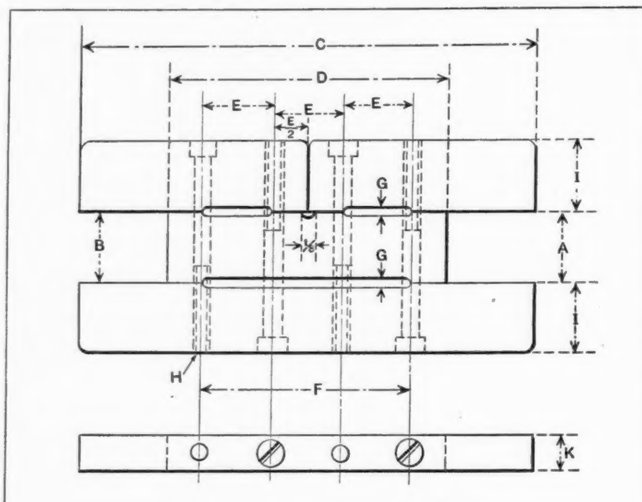



Fig. 1. Chart for determining Proportions of Gages

## REMOVING RUSTY SCREWS

Those of us whose days are spent in manufacturing shops might open our eyes in surprise if we could see the variety of tasks laid before our brother in the trade who conducts a jobbing business in the country. As he is often the only man




PROPORTIONS OF BUILT UP GAGES

| A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|
| ½ | A ± LIMIT B = | 3¼ | 2 | ½ | 1½ | $\frac{1}{16}$ | ¼ | ½ |
| ¾ | | 3¾ | 2¼ | $\frac{9}{16}$ | $1\frac{11}{16}$ | $\frac{1}{16}$ | ¼ | ½ |
| 1 | | $4\frac{3}{16}$ | $2\frac{7}{16}$ | ⅝ | 1⅞ | $\frac{1}{16}$ | ¼ | ½ |
| 1¼ | | 4⅝ | $2\frac{11}{16}$ | ¾ | 2 | $\frac{1}{16}$ | $\frac{5}{16}$ | ½ |
| 1½ | | 5⅛ | $2\frac{15}{16}$ | $\frac{13}{16}$ | $2\frac{3}{16}$ | $\frac{1}{16}$ | $\frac{5}{16}$ | ⅝ |
| 1¾ | | 5⅝ | 3⅛ | ⅞ | 2⅜ | $\frac{1}{16}$ | $\frac{5}{16}$ | ⅝ |
| 2 | | 6⅛ | 3⅜ | $\frac{15}{16}$ | $2\frac{9}{16}$ | $\frac{1}{16}$ | $\frac{5}{16}$ | ⅝ |

*Machinery*

Fig. 2. Proportions of Built-up Snap Gages

in the community, except the cross-roads blacksmith, with any knowledge of the metal-working arts, everything smaller than a locomotive and larger than a watch comes to him for repairs, and his ingenuity and resourcefulness become so highly developed that he is very seldom fazed by a job and obliged to send it out of town.

One such mechanic, however, thought that he had met his Waterloo when a sea captain brought in a sextant damaged by exposure to salt water. In order to take the instrument apart, it was necessary to remove several steel screws that were so rusted into a steel part that they defied a screwdriver. Prolonged soaking in oil having proved ineffectual, he sought the aid of a neighboring jeweler. The jeweler was also a repairer of specta-

cles, so he had abundant experience with rusted steel screws, as many men in his trade make a practice of tightening loose screws by rusting them in with potassium cyanide, regardless of the feelings of anyone who may subsequently wish to withdraw them. Carefully removing all oil, the jeweler put a bit of beeswax on each screw, heated the part until the wax melted, and easily turned them out.

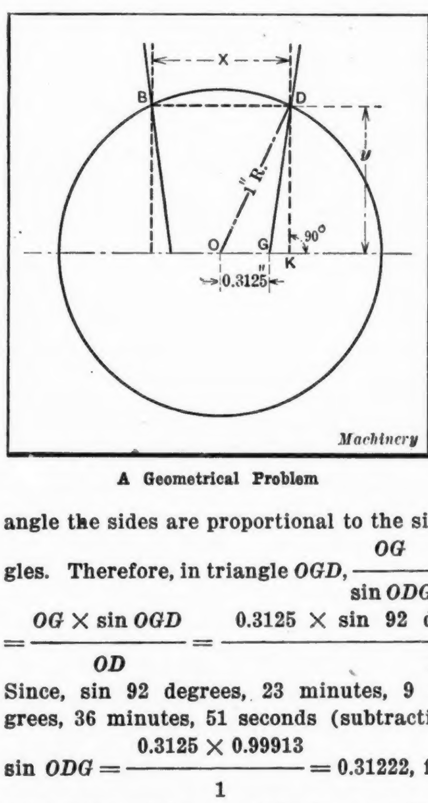
The sextant had a hardened steel worm, journaled at the ends in brass bushings fast in steel lugs. The worm was rusty and both ends were stuck to their bushings by rust. Here the machinist was on familiar ground, and needed no help. Procuring some mercury from the village drugstore, he put worm and all into it, allowing the mercury to act until the bushings were destroyed. Polishing the ends of the worm, he then made new bushings and soldered them in place. As the ordinary plumbers' solder and flux were evidently unsuited to this kind of work, he used non-corrosive fluid and 155-degree solder, both of which were furnished by the jeweler, in whose trade they are daily employed. The machinist then polished the worm thread by an old method. He turned a cylinder of soft wood, between the centers of a lathe, and mounting the worm in its own bearings on the tool-block, he fed it toward the wood until it cut grooves in the soft material. Applying fine emery and oil to this wooden "spiral gear," he soon restored to the worm its pristine finish and the sextant was ready to be assembled.

New London, N. H. GUY H. GARDNER

## THE GEOMETRICAL PROBLEM

In the January number of MACHINERY, J. J. states in "A Geometrical Problem" that neither $FD$ nor $FG$ (or its equivalent $y$) can be found by trigonometry or geometry. However, the following is a simple solution by trigonometry; see diagram. From the problem, $OG = 0.3125$, the taper of the hole is 1 inch per foot, and the radius of the circle is 1 inch. Draw $OD$ and the altitude $DK$. As angle $GDK$ = 2 degrees, 23 minutes, 9 seconds, angle $OGD$ = 92 degrees, 23 minutes, 9 seconds. According to the law of sines, in any triangle the sides are proportional to the sines of the opposite angles. Therefore, in triangle $OGD$, $\frac{OG}{\sin ODG} = \frac{OD}{\sin OGD}$, or sin $ODG$

$$= \frac{OG \times \sin OGD}{OD} = \frac{0.3125 \times \sin 92 \text{ deg., } 23 \text{ min., } 9 \text{ sec.}}{1}$$




A Geometrical Problem

Since, sin 92 degrees, 23 minutes, 9 seconds = sin 87 degrees, 36 minutes, 51 seconds (subtracting from 180 degrees)

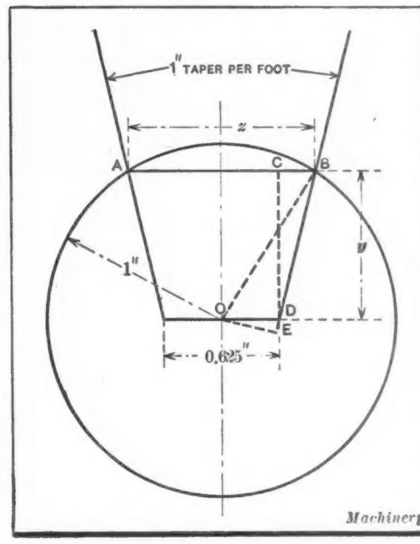
$$\sin ODG = \frac{0.3125 \times 0.99913}{1} = 0.31222, \text{ from which it is found}$$

that angle $ODG$ = 18 degrees, 11 minutes, 35 seconds. Adding angles $ODG$ and $GDK$ gives angle $ODK$ = 20 degrees, 34 minutes, 44 seconds. Then $DK$, or $y = \cos ODK \times 1$ inch = 0.93619 inch and $OK$ or $\frac{1}{2}X = \sin ODK \times 1$ inch = 0.35149 inch, making $X$ equal to 0.70298 inch.

Detroit, Mich. LOWELL C. BLOMSTROM

Referring to J. J.'s solution of "A Geometrical Problem" by analytical geometry in the January number of MACHINERY, I would like to call attention to the fact that the problem can be solved by plain geometry and trigonometry. One of the many solutions is given in the following.

Extend $BD$ to $E$, draw $DC$ parallel to the center line, and draw $OE$ at right angles to $BE$. A taper of 1 inch per foot gives an angle of 2 degrees, 23 minutes, 9 seconds, which is the size of angles $BDC$ and $EOD$. Sin $BDC$ = 0.04163, which is also sin $EOD$; and cos $BDC$ = 0.99913, which is also cos $EOD$. As $OD$ = 0.3125 inch, $OE = 0.3125 \times 0.99913$ = 0.31223 inch and $DE = 0.3125 \times 0.04163$ = 0.013 inch. $BE = \sqrt{1^2 - 0.31223^2}$ = 0.95 inch. So $BD$ = 0.95 — 0.013 = 0.937 inch. Therefore, $CD$, or $y = 0.937 \times 0.99913 = 0.93618$ inch, and $AB$ or $z = 0.625 + (1/12 \times 0.93618) = 0.70301$ inch.




A Geometrical Problem

Detroit, Mich. O. F. SCHWEITZER

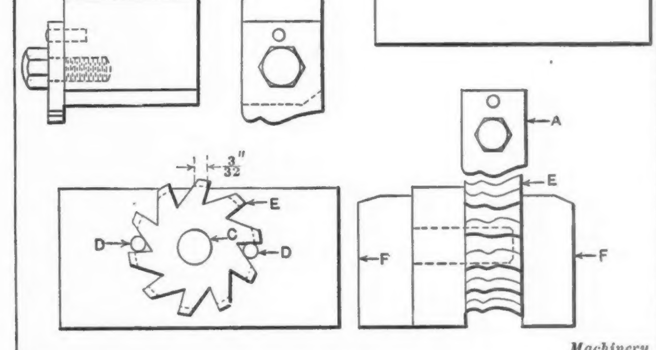
Solutions somewhat similar to these have been received from Edmund Barany of Newark, N. J., W. S. Portzinger of Lansing, Mich., and J. P. Ryan, of Hartford, Conn.—EDITOR.

## TOOLS FOR BACKING OFF FORM CUTTER

Having occasion to make a form cutter and not having a backing-off machine or attachment, the following method was adopted, which proved entirely satisfactory. A male form tool was made from a model; this tool and its holder are shown at $A$ in the accompanying illustration. Then a blank cutter was turned, with this tool located about 0.01 inch below the center of the lathe to get the proper "bite." The blank cutter was then milled for ten teeth having a land of ⅛ inch.

An indexing holder $B$ was made to back off the teeth in the crank shaper, using the same male tool with which the blank cutter was turned. This holder consists of a piece of cold-rolled steel ½ by 1½ by 3 inches, a center stud $C$ upon which the cutter revolves, and two dowels $D$. Each tooth was set forward off center 3/32 inch. The cutter and holder were held in the shaper vise and a tooth was planed at a very slow speed until the tooth was brought to the cutting edge. The micrometer stop was used on succeeding teeth.

Jersey City, N. J. WARREN H. DUNBRACK




Form Cutter and Tools for backing it off

# HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

## CENTER OF A SQUARE

W. H. H.—Will you kindly decide the following question? A claims that a square has no center—that only a circle or sphere can have a center; B claims that a square has a center. Which is right?

A.—A square figure has no center in the geometrical sense; that is, there is no point that measures the same from all points in the periphery, as is the case with the center of a circle or sphere. But a square figure has a center of gravity; that is, the point on which a plane figure will balance. The answer to the question depends on what is meant—the geometrical center or the center of gravity. In one case A is correct, and in the other, B.

## CENTRIFUGAL FORCE IN PULLEYS

H. F. C.—We have use for a small grinding wheel 1/4 inch diameter to be run at 30,000 R. P. M. by an 1800 R. P. M. motor. The first speed from the motor is secured from a 4-inch pulley which drives a 2-inch pulley; the next speed is obtained from a 14-inch pulley driving a 1 5/8-inch pulley. The countershaft on which the 2-inch and the 14-inch pulleys are mounted will run at about 3500 R. P. M. This gives the 14-inch pulley a peripheral speed of 12,800 feet per minute, which is entirely too high, of course, for cast iron. Can you tell me what peripheral speed is safe for aluminum pulleys?

A.—The specific gravity of cast iron is about 7.20 and that of aluminum 2.56; hence, cast iron is about 2.80 times as heavy as aluminum. Cast iron and aluminum are rated at about the same strength, *viz.*, 15,000 pounds per square inch cross-section. The centrifugal force developed in rotating bodies varies as the speed of the number of rotations—hence, an aluminum pulley 14 inches diameter can be run as much faster than a cast-iron pulley of the same diameter as the square root of the ratio of their specific gravities, or the square root of 2.80, which is 1.67, nearly.

## FINDING HEIGHT OF CHIMNEY

C. H. G.—We have a tall chimney at our factory and wish to find its height without plumbing it; how can this be done?

A.—Referring to the illustration, set up a transit at *B*, measure very carefully the distance *BA*, sight the telescope to the top of the chimney, and measure the angle *CBA*. Then, in the right triangle *CBA*, right-angled at *A*, the side *AB* and the angle *B* are known, from which the height *AC* can readily be found. If no transit is at hand, the height can be determined quite closely in the following manner: Select a time when the sun is about midway between the horizon and the zenith, so that it will cast a comparatively long shadow. Take a pole of some convenient length, the longer the better, stand it upright so that the end of its shadow will just reach to the end of the shadow cast by the chimney, and measure the distance from the pole to the end of its shadow, which will be the same as the distance *EB*. Also measure the length of the shadow cast by the chimney, which corresponds to the distance *AB*. Then, from the similar triangles *ACB* and *EDB*, $AC\ (=x) : ED = AB : EB$. Suppose $AB$ = 92 feet, 8 inches, $EB$ = 11 feet, 5 inches, and the pole is 9 feet long; then $x : 9 = 92\ 8/12 : 11\ 5/12$, or $x : 9 = 1112 : 137$; from which $x = 73$ feet, very nearly, which is the height of the chimney. J. J.

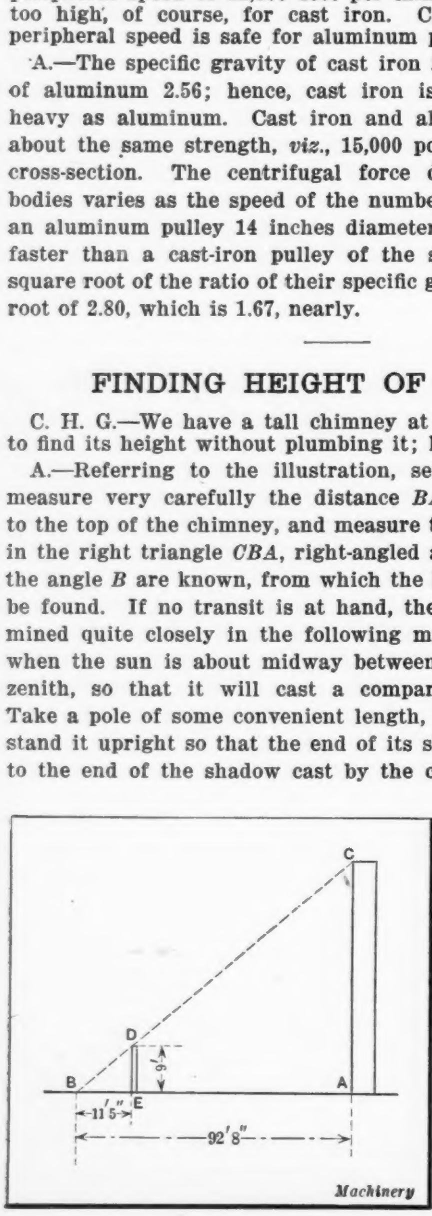
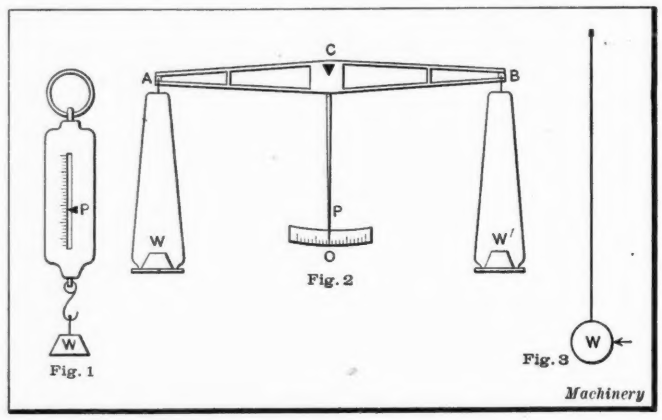



Diagram for finding Height of Chimney

## ABSOLUTE MEASURE OF FORCE

H. A. E.—Please state what is meant by absolute measure of force. What does "absolute" mean in this case, and also, in the expression "absolute term?"

A.—Roughly speaking, absolute may be defined as unchangeing, or unchangeable. In an equation like $7x^3 - 23x^2 + 96x - 215 = 0$, the term—215, is called the absolute term because its value is always the same, regardless of what value or values may be assigned to $x$. A force is measured by the effects it will produce; and one way of measuring a force is by using a spring scale, as shown in Fig. 1. The weight $W$ pulls the indicator $P$ to a certain mark on the scale, thus not only indicating the weight of $W$ but also the force with which $W$ stretches the spring. This method of measuring force is inconvenient, for the reason that we need the same mass to indicate always the same force when used as a measure of force. In the present case, the weight of the body $W$ (and, consequently, the pull on the spring) will depend on where the body is weighed, whether at sea level or otherwise, and on the latitude of the place, the barometric pressure, the temperature of the air, etc. If, however, a beam scale, Fig. 2, is used, and the arm $AC$ equals the arm $BC$, the pointer $P$ being at 0 when no weights are in the scale pans, a weight $W$ in one scale pan must exactly equal a weight $W'$ in the other, in order to keep the pointer at 0. If $W$ is known, an equal mass $W'$ can easily be found, regardless of any of the conditions just mentioned. In so far as the earth's surface is concerned, the measurement of $W'$ will be absolute; but at the center of the earth or at a certain point between the earth and the moon, for example, where the body has no weight, a beam scale could not be used either. Suppose that the weight $W$ is suspended from a cord, say a mile long, as in Fig. 3, and that a force acting on it causes the weight to move a foot in a certain time, and at the end of this time, to have a velocity $v$. The path may be assumed to be a straight line. If the force is doubled, the velocity at the end of the same time will also be doubled; and if the force is halved, the velocity at the end of the same time will be halved. Since the mass of a body is absolute (it depends only on the amount of matter that the body contains), we have here a way of determining an absolute measure for force, and may say that the absolute unit of force is that force which acting on a mass of one gram for one second, produces a change of velocity of one centimeter per second; this force is called one dyne, and is also called the C. G. S. (centimeter-gram-second) unit of force. J. J.

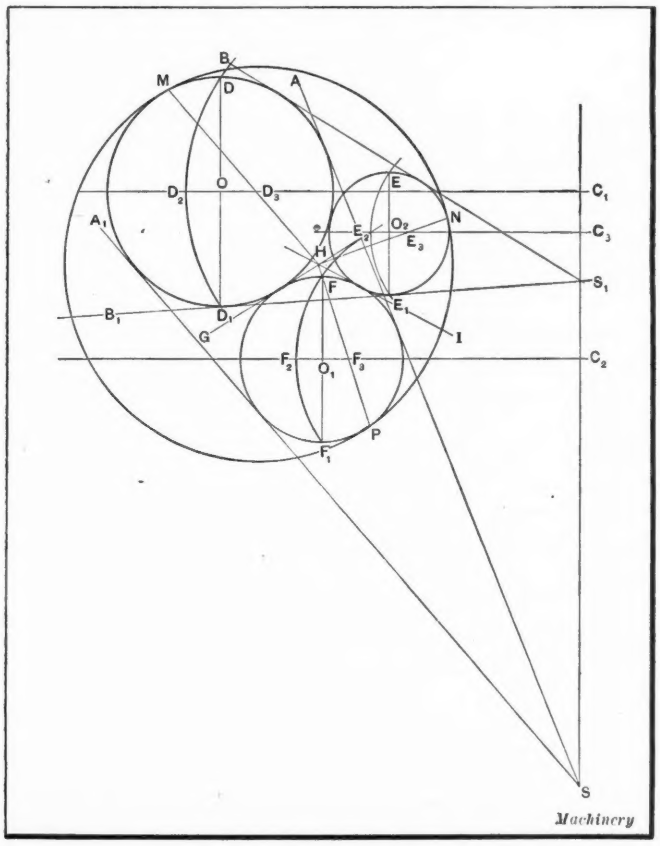



Figs. 1 to 3. Methods of measuring Force

## TO DRAW A CIRCLE TANGENT TO THREE GIVEN CIRCLES

**M. A. C.—Is there any exact geometrical construction for drawing a circle tangent to three circles that are tangent to each other? For example, if the diameters of three circles are 2, 1 7/16, and 1 1/16 inch, what is the smallest circle that will enclose them?**

A.—There is no method known to the writer whereby this problem may be solved by applying the principles of what is called Euclidean geometry—the kind that is ordinarily studied in schools. It may be solved, however, by what is called modern or profective geometry (although the construction is not easy) in the following manner: Let $O$, $O_1$, and $O_2$ be the




Method of drawing a Circle Tangent to Three Given Circles

centers of the three given circles. Draw $AS$ and $A_1S$ tangent to the two circles $O$ and $O_1$, intersecting at $S$; draw $BS_1$ and $B_1S_1$ tangent to the two circles $O$ and $O_2$, intersecting at $S_1$; draw $S_1S$. Through the centers of the given circles, draw $OC_1$, $O_1C_2$, and $O_2C_3$, all perpendicular to $S_1S$. Draw the diameters $DD_1$, $EE_1$, and $FF_1$ parallel to $S_1S$. Through the three points $D$, $D_1$, $C_1$, the three points $E$, $E_1$, $C_3$, and the three points $F$, $F_1$, $C_2$, pass arcs of circles intersecting $C_1O$, $C_3O_2$, and $C_2O_1$ in $D_2$, $E_2$, and $F_2$, respectively. On $OC_1$ lay off $OD_3 = OD_2$; on $O_2C_3$ lay off $O_2E_3 = O_2E_2$; and on $O_1C_2$ lay off $O_1F_3 = O_1F_2$. Now draw $GH$ tangent to the circles $O$ and $O_1$, and draw $IH$ tangent to the circles $O_1$ and $O_2$; they intersect at $H$. Draw $HD_3$, $HE_3$, and $HF_3$; they intersect the three circles in $M$, $N$, and $P$, the points of tangency for the circumscribing circle. Through $M$, $N$, and $P$, by the usual construction, pass a circle; this will be the circle sought. J. J.

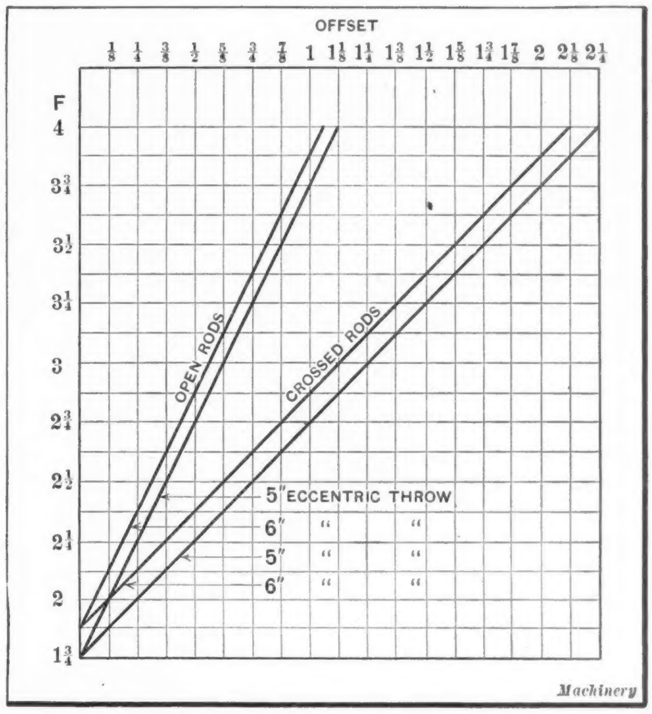



**Fig. 2. Chart for determining Amount of Offset of Saddle-pin**

## OFFSET OF SADDLE-PIN OF STEPHENSON LINK MOTION

**H. L. W.—The writer has been unable to find any formula for calculating the offset of the saddle-pin of the Stephenson link motion. The need for offset is mentioned in works on locomotive design, but no rule is given for obtaining it.**

A.—The general practice of locomotive builders has been to determine the offset of the saddle-pin by trial, using a saddle with slotted holes in the pad to permit it to be adjusted until the irregularities introduced by the angularity of the connecting-rod are compensated for. No practicable formula is known by which the offset can be calculated, but C. J. Mellin, consulting engineer of the American Locomotive Co., has kindly furnished the accompanying data, which may be used in finding the offset without trial. The method was worked out on a valve model with given dimensions of gear as a base, variations being made of these dimensions and other conditions. The offset is obtained by additions and subtractions as indicated in the following: The model or base dimensions, Fig. 1, are as follows: $A = 96$ inches; $B = 24$ inches; $C = 48$ inches; $D = 12$ inches; $E = 1/2$ inch.

*Example:* Given a valve motion of the "open rods" type in which $A = 108$ inches; $B = 26$ inches; $C = 60$ inches; $D = 13$ inches; and $E = 0$ inch to find the offset, the eccentric throw being 5 inches, and $F$, 3 inches. The base figure of the offset is 5/8 inch, found in the diagram Fig. 2. The amounts added to the base or subtracted from it are taken from the following for "open rods":

Add 1/16 inch to offset for each additional 12 inches to $A$; subtract 1/32 inch from offset for each additional 2 inches to $B$; subtract 1/16 inch from offset for each additional 12 inches to $C$; subtract 1/4 inch from offset for each additional 1 inch to $D$; add 1/16 inch to offset if $E$ is 0, from which we obtain 5/8 + 1/16 — 1/32 — 1/16 — 1/4 + 1/16 = 13/32 inch offset.

If the valve

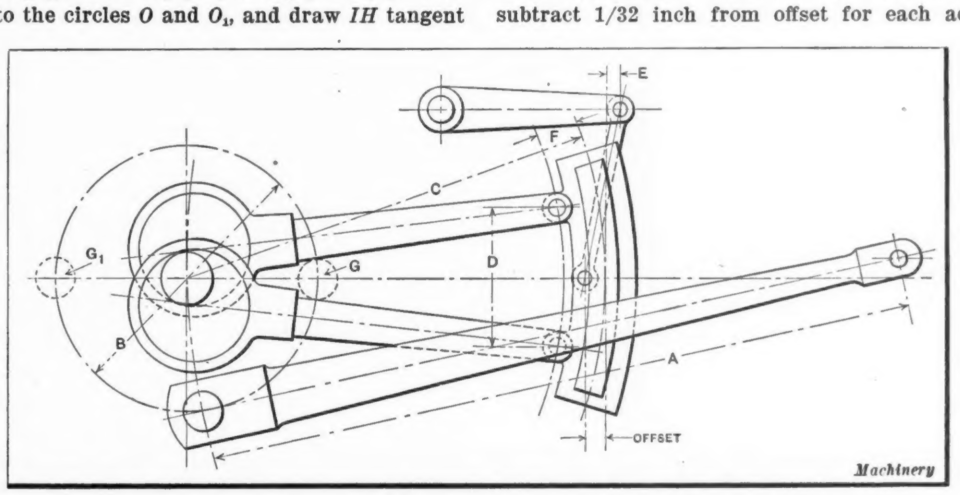



**Fig. 1. Model of Stephenson Link Motion used as Base for finding Offset of Saddle-pin**

motion is of the "crossed rods" type, then add 1/8 inch to offset for each additional 12 inches to $A$; subtract 1/16 inch from offset for each additional 2 inches to $B$; subtract 1/8 inch from offset for each additional 12 inches to $C$; subtract 1/2 inch from offset for each additional 1 inch to $D$; add 1/8 inch to offset if $E$ is 0. If too much offset is given, the cut-off will be longer on the front end of the cylinder than on the back with open rods, and *vice versa* with crossed rods.

The connecting-rod is shown out of position in Fig. 1 for the sake of clearness. The crank-pin will be at $G$ if the valve motion is of the "open rods" outside admission valve type and at $G_1$, if of the "crossed rods" type.

## STRENGTH OF A RIBBED PLATE

N. F. F.—The ribbed cast-iron plate shown in Fig. 1 is uniformly loaded over a surface 29 inches in diameter at the center and firmly supported at the four corners. What load will it safely support and at what load will it fail?

Answered by John S. Myers, Philadelphia, Pa.

There is always more or less uncertainty as to the strength of ribbed cast-iron sections on account of shrinkage strains, blow-holes, and other inherent defects which may develop

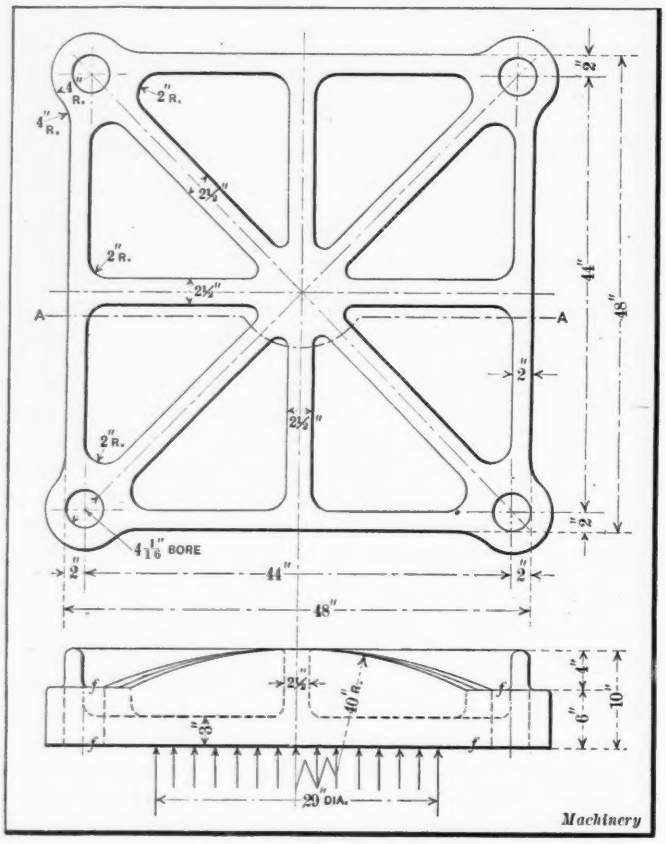



Fig. 1. Dimensions of Ribbed Plate

under load but which may not be apparent to the inspector. This is especially true of those cases where the ribs are under tension, as in the present example. In view of such considerations some designers virtually neglect the ribs when estimating the strength, treating the casting as a flat plate slightly thicker than the actual plate, thus allowing something for the stiffening effect of the ribs. While this rough and ready method has simplicity in its favor, and may be quite satisfactory when applied with discretion, it is not very satisfying from a technical viewpoint. If the ribs are of no calculable value, why not omit them from the casting as well as from the calculations? The logical method seems to be to calculate the strength based on the full value of the ribs and allow a stress sufficiently low to take into account possible imperfections in both theory and practice.

Assuming the casting to break along the line A–A, the section would be about the equivalent of that shown in Fig. 2. The area of the section is $A = 7 \times 11.5 + 3 \times 48 = 224.5$ square inches. Taking moments of the areas about the center of the three-inch plate, the distance to the center of gravity is

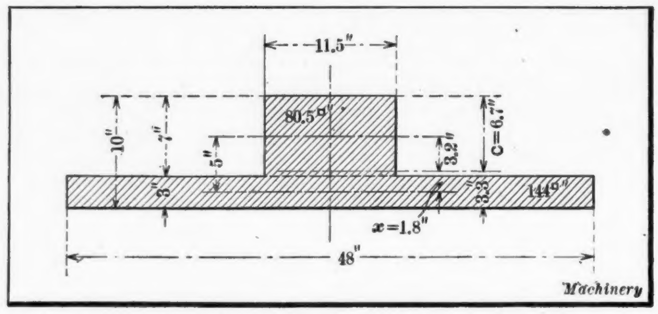



Fig. 2. Equivalent Section through Casting on Line A-A

$$x = \frac{7 \times 11.5 \times 5}{224.5} = 1.8 \text{ inch, approximately.}$$

Taking the areas times the square of their distance from the center of gravity, plus their moment of inertia about their own axis, the moment of inertia of the section is $I = 80.5 \times 3.2^2 + 144 \times 1.8^2 + \frac{11.5 \times 7^3}{12} + \frac{48 \times 3^3}{12} = 1727$. The section modulus for the tension side is then $Z = \frac{I}{C} = \frac{1727}{6.7} = 258$.

The casting may now be considered as a beam loaded as indicated in Fig. 3, when the bending moment is $M = \frac{W}{2} \times 22 - \frac{W}{2} \times 6 = 8W$. The general formula for the relations of moment $M$, stress $S$, and section modulus $Z$ is $M = SZ$. Assuming a value of $S = 4000$ and substituting the values of $M$ and $Z$ gives $8W = 4000 \times 258$ or $W = 129{,}000$ pounds as the safe load based upon the comparatively high working stress in the tension side of the ribs of 4000 pounds per square inch. If the load is suddenly applied or the casting is subjected to shock, about half this value will represent the safe load.

Since the elasticity of cast iron in tension and compression is not the same, $\frac{I}{C}$ does not represent the true section modulus, being only approximately true. Also the expression $M = SZ$ is only supposed to hold good within the elastic limit, and with strict propriety cannot be applied for the breaking load. However, in view of the other uncertainties of the problem, precision is far from attainable and this relation may be assumed to be approximately true for the breaking load also. Taking a stress of 16,000 pounds per square inch, which is four times the assumed working stress, failure would occur at a load of approximately $4 \times 129{,}000 = 516{,}000$ pounds; but if the plate is subjected to shock, a load less than half this amount might cause failure.

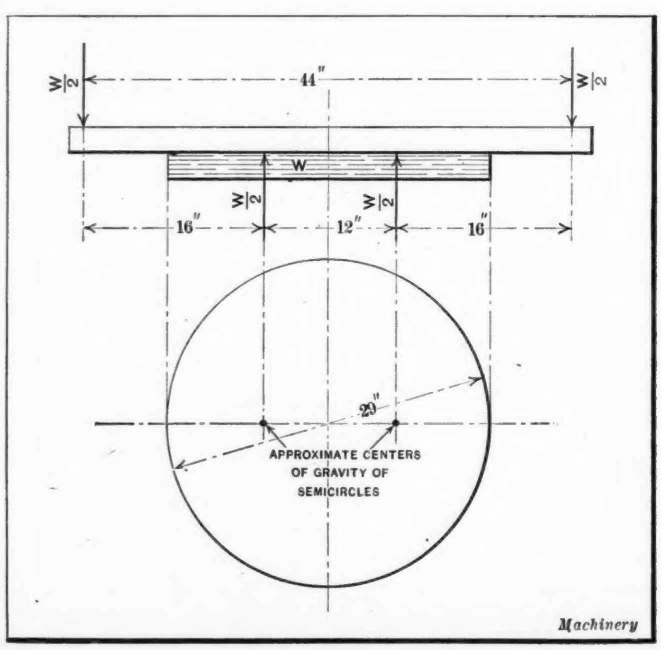



Fig. 3. Loading as a Beam

## CONRADSON PLAIN MILLING MACHINE

*This machine is arranged with a duplex helical drive to the spindle which, in connection with changes obtained from sliding gears in the speed-box, affords twelve speed changes from 12 to 275 revolutions per minute. This is the feature which represents marked departure from standard practice in the design of plain milling machines.*

C. M. Conradson of Eau Claire, Wis., is now building a No. 3 plain milling machine with single-pulley drive, which is illustrated and described herewith. It will be seen that, in a general way, the design of this machine follows established practice, except for the arrangement of the speed and feed gearing. It is worthy of notice, however, that the machine is of exceptionally heavy construction. The duplex helical drive to the spindle is similar to that employed on the Conradson engine lathe. From the single driving pulley, which is 14 inches in diameter by 4 inches face width, power is transmitted through heat-treated, chrome-nickel steel change-gears, which furnish the desired range of speeds. These gears are mounted in a cylindrical case which may be oscillated in such a way that engagement is made between either a worm and a worm-wheel keyed to the milling machine spindle or between a spiral pinion and a spiral gear keyed to the milling machine spindle. Thrust is taken by heavy-duty S.K.F. ball bearings.

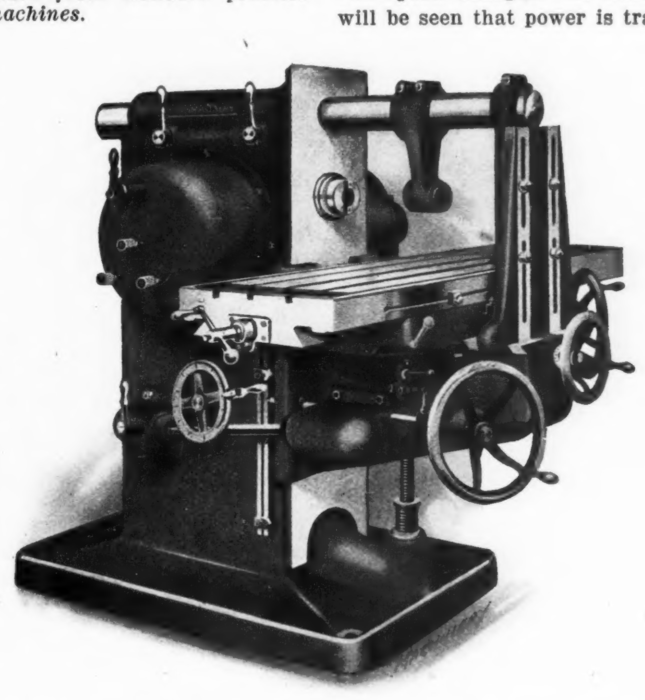


Fig. 1. Conradson No. 3 Plain Milling Machine with Duplex Helical Drive

This arrangement will be readily understood by reference to Fig. 3, which shows the mechanism in detail. It will be seen that driving pulley *A* is provided with a friction clutch *B* for engaging or disengaging the drive. This clutch is secured to shaft *C* that runs through the center of sleeve *D*. Carried at the left-hand end of shaft *C* are two sliding gears *E* and *F* which may be engaged with gears *G* and *H* to secure the first two speed changes. In either position of gears *E* and *F*, it will be seen that power is transmitted back through pinion *I*, which is keyed at the left-hand end of sleeve *D*. A third speed change is secured by sliding gears *E* and *F* to their extreme right-hand position, so that the clutch teeth on gear *F* engage direct with corresponding clutch teeth on pinion *I*. In this position, gears *G* and *H* will continue to revolve on the intermediate shaft, but they play no part in the transmission, as a direct high-speed drive is secured through sleeve *D*.

Near the center of sleeve *D* there are mounted two pinions *J* and *K* that mesh with sliding gears *L* and *M* on the lower shaft in the speed-box. Gear *M* may be engaged with pinion *J*, as shown, or the gears may be slid over to bring gear *L* into engagement with pinion *K*. Of course, it will be evident that the operation of sliding gears *E* and *F* is controlled by knob *N*, while operation of sliding gears *L* and *M* is controlled by knob *O*, spring plungers being provided to enter notches in the rods that carry these knobs when the sliding gears are engaged in various positions. From shaft *P* in the speed-box, power is transmitted to the milling machine spindle by rocking the cylindrical speed-box to engage worm and wheel *Q* or spiral gears *R*, in the manner to which refer-

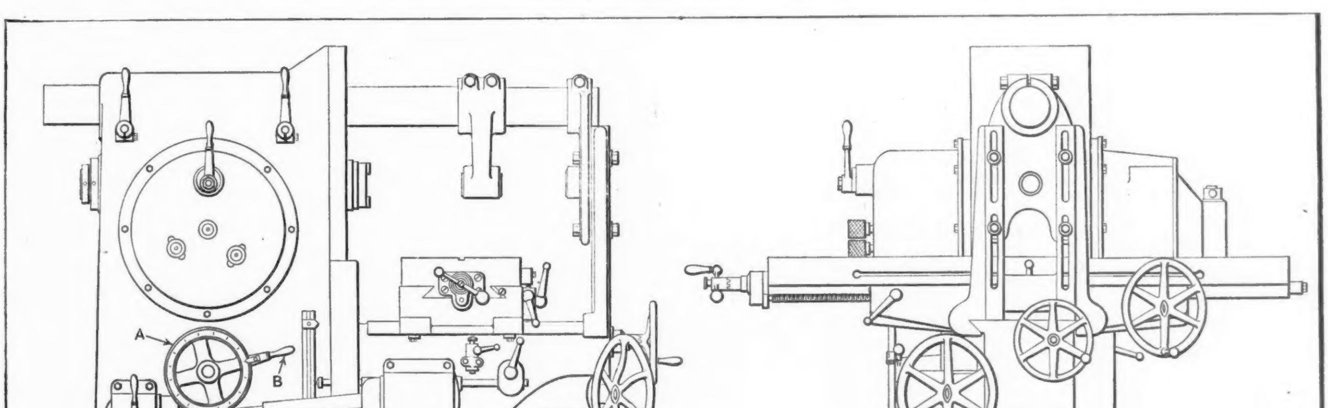



Fig. 2. Side and Front Views of Conradson No. 3 Plain Milling Machine shown in Fig. 1

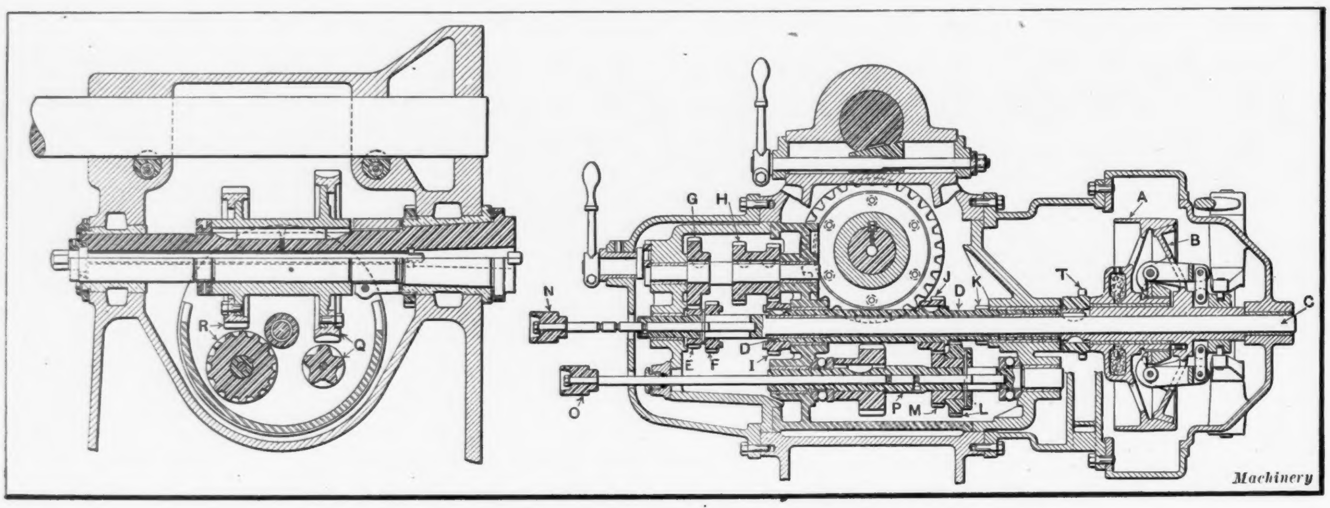



Fig. 3. Cross-sectional View through Speed-box showing Arrangement of Change-gears

ence has already been made. The worm drive and the spiral gear drive are of widely different ratio, thus providing a greater range of spindle speeds than would otherwise be obtainable. Also, these helical gear drives furnish an exceptionally smooth transmission. Rocking of the speed-box to engage either the worm-wheel or spiral gear drive is controlled by a lever. This mechanism provides twelve changes of speed, covering a range of from 12 to 275 revolutions per minute, the changes being in practically geometrical progression.

Power for operating the feed mechanism is transmitted to the gear-box by means of a chain drive from sprocket *T*, Fig. 3. This feed-box is arranged with a cone of gears, the desired rate of feed being obtained by engaging the proper gear ratio with a diving key. Movement of this key is controlled by a screw, at the end of which is located dial *A*, Fig. 2, which is graduated to facilitate obtaining the desired rate of feed. This mechanism, in connection with compounding lever *B*, provides for securing sixteen changes of feed, ranging from ½ inch to 20 inches per minute. The feed can be changed while the machine is running, and the direct-reading index on dial *A* obviates the necessity of using tables. All feeds are instantly reversible.

The over-arm is made of steel, and is 4¼ inches in diameter; this arm is clamped by wedges actuated by two levers that will be seen at the top of the machine. The maximum distance from the center of the spindle to the under side of the arm is 6⅜ inches, and the maximum distance from the end of the spindle to the arbor support is 25¼ inches. Two arbor supports are furnished, one of which supports the end of the arbor, and the other the middle. The front spindle bearing is 4¼ inches in diameter; and the spindle has a No. 11 taper hole and a 13/16-inch hole running through it. A faceplate forged integral with the spindle provides for driving face cutters.

The table is 12¾ by 63¼ inches in size, and the working surface is 12¾ by 53 inches in size. There are three ⅝-inch T-slots in the table, and the table feeds 34 inches in either direction. Each operating screw is provided with a graduated dial reading to 0.001 inch, and all handwheels are clutched. The maximum cross-feed is 10 inches, and the maximum vertical feed is 20 inches. The vise furnished with the machine has jaws 6 1/8 inches wide by 1 9/16 inch deep, and has a maximum opening of 3 5/8 inches. The floor space occupied by the machine is 96 inches in line with the spindle by 115 inches at right angles to the spindle; and the net weight of the machine is 4750 pounds.

## LANDIS FLOOR-TYPE BORING, MILLING AND DRILLING MACHINE

The Landis Tool Co., Waynesboro, Pa., is now manufacturing a horizontal floor type of boring, milling and drilling machine designed to insure durability, simplicity of operation, and adaptability for a wide range of work. This machine may be used not only for boring, drilling and milling, but for tapping, splining, oil-grooving and rotary planing operations. It is driven from a motor mounted on top of the column. The drive is direct-connected to the main drive shaft, there being no belting whatever. The spindle drive is controlled by a pair of friction cone clutches, located at the back of the saddle and accessible for adjustment. This arrangement provides a reversal of the spindle for back facing and tapping.

The driving pinion for the spindle meshes with a large gear, the teeth of which are integral with the faceplate. This location of the spindle driving gear, by eliminating torsional strains, prevents one of the most frequent causes of chatter when milling. The front end of the spindle slides through an adjustable bearing carried on the spindle sleeve, but the spindle does not rotate in this bearing. The rotation

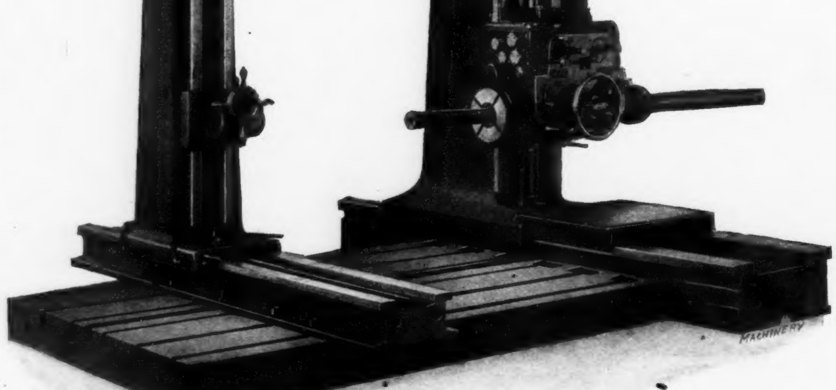


Fig. 1. Landis Floor Type of Horizontal Boring, Milling and Drilling Machine

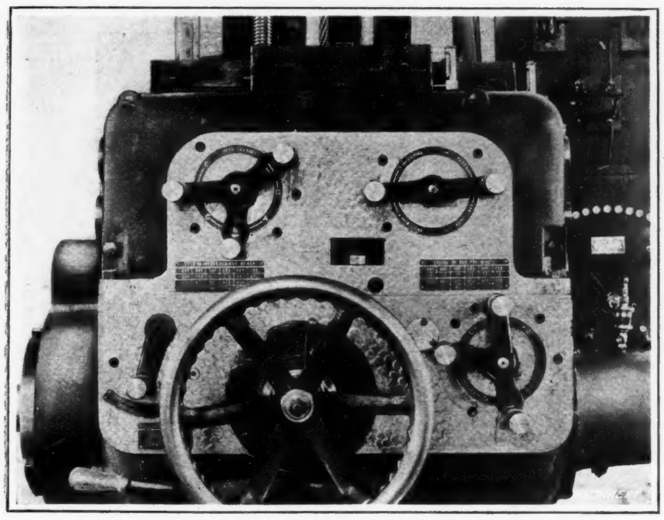


Fig. 2. Saddle of the Landis Boring, Milling and Drilling Machine

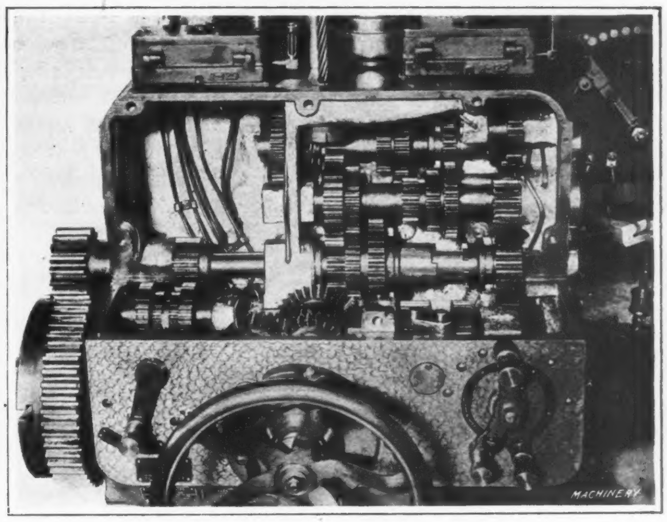



Fig. 3. Spindle Driving and Feeding Mechanism

is in another adjustable bearing, and on the external diameter of the spindle sleeve. The advantage of this design is in the provision for taking up wear on the sliding spindle bearing.

A prominent feature of this tool is the concentric screw feed of the spindle, accomplished by means of a differential train of gears. This method of feeding permits continuous traverse of the spindle without resetting. The feed is applied between the main bearings, and requires no overhanging support at the end of the saddle. The spindle is traversed by a long bronze nut, which engages a square thread on the spindle and which has a bearing only on the sides of the thread. This arrangement provides a long bearing, and the nut and spindle rotate together at the same rate of speed, except when the feed is engaged. The end thrust in the spindle, in either direction, is taken on ball bearings.

The thrust of the spindle when milling is taken directly on the main saddle casting, and is entirely independent of the end thrust of the spindle for boring. The application of feed and speed gear trains in the saddle, as one unit, gives a centralized and convenient control.

Twelve changes of feed and twelve changes of speed are available. All feeds are per revolution of the spindle and are identical whether applied to the spindle, saddle or column traverse, and no two feeds can be engaged at the same time. Any one of the twelve feeds can be used in connection with one of the twelve spindle speeds. Power rapid traverse, independent of the regular feeds, is provided for the spindle, saddle and column in every direction. With one lever, the machine can be instantly started and stopped, or reversed, independent of the main drive or motor.

The gear shifts are all of the sliding transmission type, and are tightly enclosed. This feature adds not only to the life and appearance of the machine, but also provides safety for the operator. All traversing gears are located between the ways, and close to the guiding side. The gears and shafts are made of chrome-nickel steel specially heat-treated. The spindle is made of high-carbon hammered crucible steel and is accurately ground to secure correct alignment. The oiling of the saddle parts is accomplished by the syphon system, which insures a continuous supply of clean oil to the bearings. The counterweight for the saddle operates inside the column, out of the way of the operator, thus assuring safety in accordance with state laws.

When a swivel table is used with this machine, the different sides of work may be finished without resetting. Scales and verniers reading to thousandths of an inch are provided for locating either the main or outer supporting saddles and columns in the desired positions. There is also an adjustable dial reading to thousandths of an inch for use in connection with the spindle.

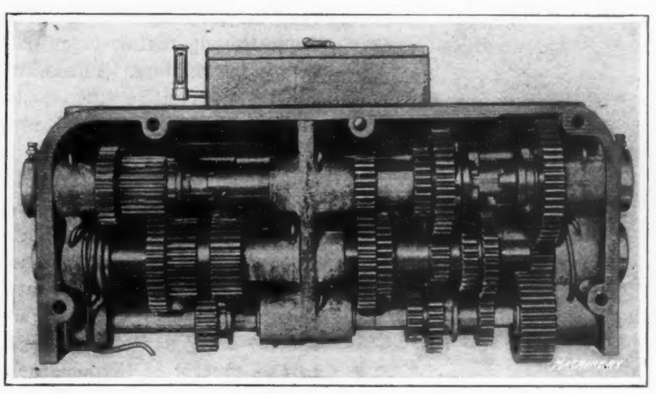



Fig. 4. Section removed from the Saddle shown in Fig. 3

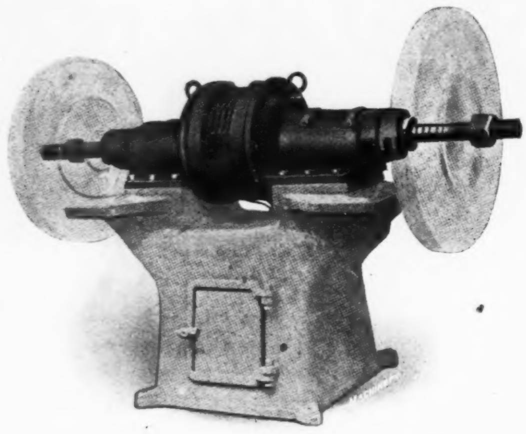
The column is of very heavy construction and has a liberal bearing surface on the horizontal runway. It may be adjusted along this runway either by hand or power, and is provided with reversible feeds for milling and a rapid traverse. The spindle has a continuous feeding movement of 40 inches; the minimum distance from the center of the spindle to the floor plate is 18 inches, and the maximum distance, 72 inches. The maximum distance from the faceplate to the outer spindle support is 88 inches. This machine has been designed especially to meet the requirements of shipyards, navy yards, turbine works and similar plants, and it is capable of handling a wide range of heavy work.

## WESTINGHOUSE GRINDER MOTOR

The grinder motor illustrated has been recently placed on the market by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. It is designed for use on two- and three-phase, sixty-cycle, alternating-current circuits, and is constructed especially to meet the severe conditions to which such motors are subjected in grinding and polishing work. This grinder motor is obtainable in three sizes, having capacities of 5, 7½ and 10 horsepower, respectively. The 7½- and 10-horsepower two-phase motors are supplied with automatic starters. For the 5-horsepower two- and three-phase motors, an ordinary knife switch is employed, and a special starting switch for the 7½-horsepower two- and three-phase motors. Pedestal bases, grinding wheels, and tool-rests are furnished by the grinding machine manufacturer.

To protect all parts against wear and injury from grit and metallic dust, the bearings are made dustproof, and the motor is wholly enclosed. A large radiating surface is provided, however. The end brackets are solid and are cast integral with the feet, which are extra heavy and arranged so that they can be bolted rigidly to the pedestal. The heavy grinding wheels with which these motors are designed to be used put a great strain on the shaft and bearings. These parts are therefore made extremely strong and rugged. The shaft, which is made of axle steel, is of extra large diameter, and is extended at both ends to receive the grinding wheels. The bearings, which are the only wearing parts, have large bearing surfaces, insuring long life. Each is thoroughly lubricated by two oil-rings. The end thrust is taken up by adjustable collars.

The rotor of the motor, which is of the squirrel cage form, cannot be damaged. There are no moving contacts. The rotor bars are firmly fastened in the iron core and are short-circuited by end rings. No bolts or screws are used, and there is nothing about the rotor that can work loose even under the most severe service, or that will deteriorate under heat. The stator winding is thoroughly treated with an oil- and moisture-resisting varnish. In motors larger than five horsepower, the winding



Alternating-current Grinder Motor made by Westinghouse Electric & Mfg. Co.

consists of coils wound on forms and completely insulated, then laid in the open stator slots and securely held in place by means of wedges.

## BRISTOL AUTOMATIC TEMPERATURE CONTROLLER

In the field of temperature measurement as applied in industrial works and manufacturing plants the logical steps are, first, to measure and indicate the temperature with a reading instrument; second, to automatically record the temperature with a graphic recording instrument; third, to automatically control the temperature. At this time the manufacturers are endeavoring to use automatic apparatus wherever possible, thus eliminating the personal element, and there is a demand for automatic temperature controllers in many processes. The Bristol Co., Waterbury, Conn., has developed a comprehensive new line of automatic temperature controllers for gas- and oil-fired and electrically heated furnaces. The new Bristol tem-


Fig. 1. Measuring and Controlling Elements—Thermo-electric Type

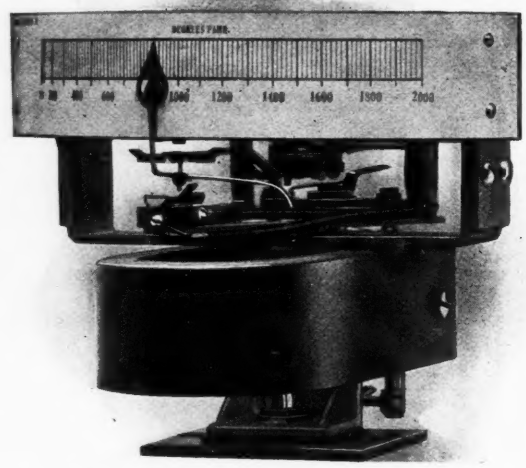


Fig. 2. Interior View of Controlling Element

perature controller employs three elements: a measuring element, a contacting element and an operating element.

The measuring element consists of a number of different types of Bristol electric pyrometers and thermometers; notably the Bristol thermo-electric pyrometer with Weston millivoltmeter movement and patent Bristol separable couples, also the Bristol vapor-filled type of thermometer which is extensively used for recording temperatures. The controlling element is combined with the measuring element and consists primarily of a patented electrical contact closing device, which operates at predetermined high and low temperatures, and by means of which electrical circuits are closed or opened, thus energizing or disconnecting the operating element. The operating element consists of the device which actually regulates the heat supply in the furnace; as, for instance, in the case of a gas-fired furnace, a pair of electrically operated gas and air valves, and in the case of an electric furnace a special relay switch opening and closing the circuits of the heating element of the furnace.

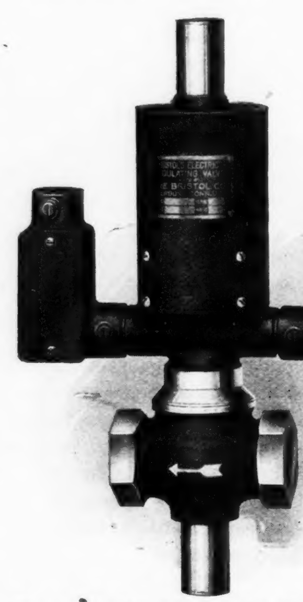


Fig. 3. Special Gas and Air Valve used in Connection with Gas Furnaces

Construction details of the new Bristol temperature controllers may be seen by reference to the accompanying illustrations. Fig. 1 shows an external view of the measuring and controlling elements of the thermo-electric type, and Fig. 2 is an interior view of the controlling element, from which it may be seen that the indicating arm is completely insulated from the operating circuits. The contacting device is absolutely frictionless. These Bristol thermo-electric temperature controllers can be furnished for all temperatures up to 3000 degrees F., and with high resistance movements for use either with base or precious metal couples. Fig. 3 shows one of the special gas and air valves, two of which are used in connection with gas furnaces if air is supplied at pressure, and both gas and air valves are operated simultaneously so as to insure having the proper mixture at all times.

Fig. 4 shows one of the vapor type Bristol thermometer-thermostats, complete with sensitive bulb and connected to the special relay switch employed for adapting these instruments to the control of temperatures in electric ovens and furnaces. Fig. 5 shows an interior view of a similar Bristol thermometer-thermostat. The special design of contact closing device has

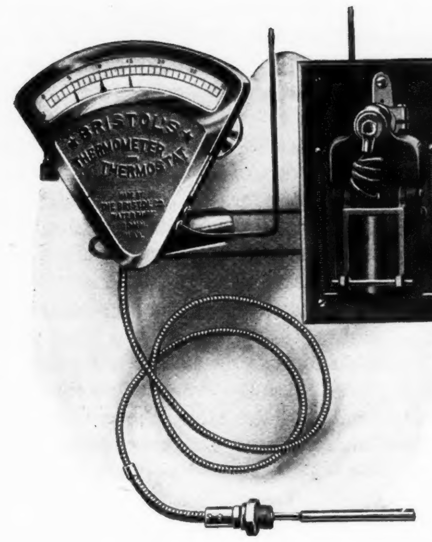


Fig. 4. Vapor Type of Bristol Thermometer-thermostat connected to Special Relay Switch

proved durable in long continued service. Both the high and low contacts are shown in this illustration, but with the Bristol automatic electrical controlling valves for both gas and air supply, only one contact is required. These temperature controllers are needed for a great variety of applications

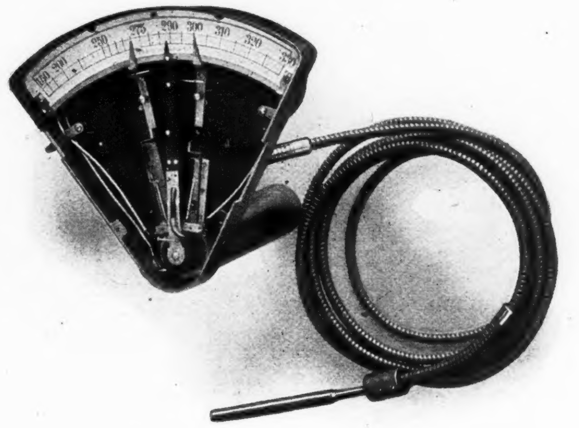


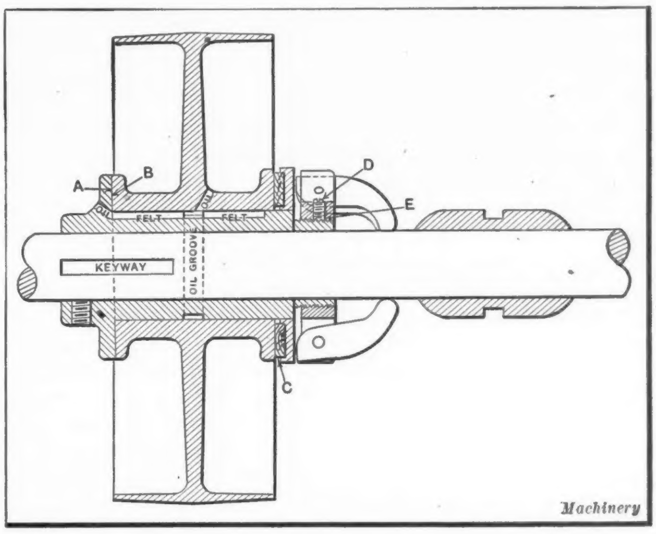
Fig. 5. Interior View of Bristol Thermometer-thermostat

and may be adapted to hundreds of processes where similar Bristol instruments are already being used successfully for measuring and recording temperature.

## NATIONAL FRICTION CLUTCH

In the "Crowley" friction clutch, which has just been placed on the market by the National Clutch Co., Fulton and Lincoln Sts., Chicago, Ill., use has been made of what are known as "friction wedge plates." There are two of these plates, and they are transversely tapered and work in opposite directions; plate *A* is part of the hub keyed to the driving shaft, so that this is the driving member, and plate *B* is part of the pulley and rotates freely upon the hub that carries plate *A*. When the three fingers are pressed against compression plate *C*, it forces the pulley along the hub so that the tapered faces of plates *A* and *B* are brought into contact. As previously mentioned, these plates are transversely tapered and they work in opposite directions. Plate *B* is driven by the belt on the pulley, and plate *A* is keyed to the shaft to provide for carrying the load; when the clutch is first engaged, frictional contact between plates *A* and *B* starts the machine, and then as the load is picked up, the two friction plates, working in opposite directions, bring the two wide parts of the plates together, thus increasing the pulling power of the clutch.

There are three longitudinal grooves in the hub, one of which is shown in the illustration, which run the full width of the pulley; also there is a circular groove running around the hub at right angles to the axis of the shaft. The longitudinal grooves are filled with felt, which becomes saturated with oil and provides the clutch with a lubricating system that has sufficient capacity for one month's service. Adjustment of the clutch is taken care of by loosening setscrew *D* in spider *E* and turning this spider on the threaded part of the hub, to the right to tighten, and to the left to loosen. These clutches are heavily constructed to adapt them

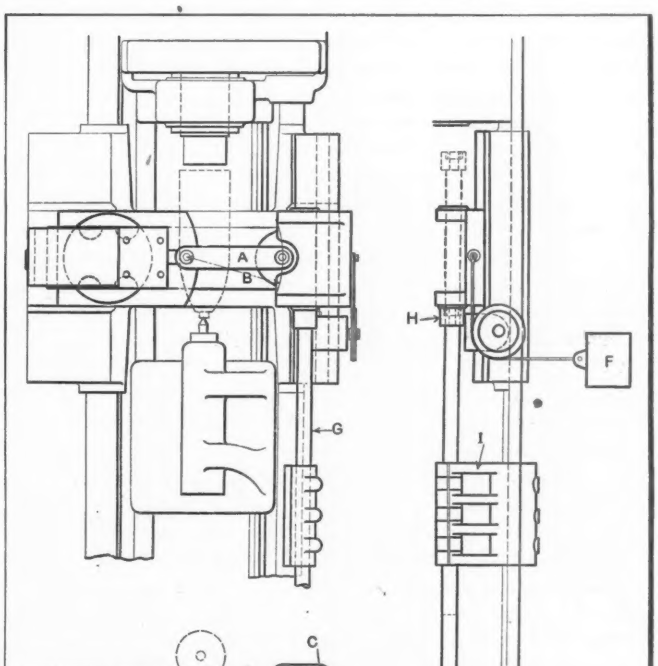



"Crowley" Friction Clutch made by National Clutch Co.

for severe service; at the same time, they are of compact construction, operate easily, and release instantly. "Crowley" friction clutches are built in sizes from 2 to 20 inches in diameter.

## AUTOMATIC PROFILING ATTACHMENT

Houston, Stanwood & Gamble Co., Cincinnati, Ohio, is now manufacturing an automatic profiling attachment which forms the subject of the following description. This device consists of a radius rod *A* with a distance between its centers equal to radius *B* of the nose of the shell. One end of this radius rod




Shell Profiling Attachment for Lathes

turns on a pin fastened to the cross-slide that carries the tool, while the pin at the other end of the radius rod is attached to a slide *C* that moves along a longitudinal guide *D* attached to the rear of the carriage. There is a stop *E* on this longitudinal guide against which the slide is held by means of a weight *F*, which is attached to the slide by a wire cable and pulley. In addition to the parts referred to, there is a bar *G* with a cap *H* and powerful clamp *I*, by means of which the stop-bar is located and held in the desired position.

In this diagram it is assumed that the shell will be machined in the usual position with its nose toward the tailstock of the lathe. As the longitudinal guide and the slide which it carries move with the carriage, the cylindrical portion of the shell is turned in the same way as it would be on a lathe without a profiling attachment. When the carriage reaches the position shown in the diagram, at the beginning of the curvature of the shell nose, slide *C* engages cap *H*, which prevents further movement of the slide relative to the bed of the lathe and to the shell; but the carriage and tool continue their longitudinal movement, which causes rod *A* to move through the sector of a circle. In this way, the cross-slide is moved in to form the nose of the shell.

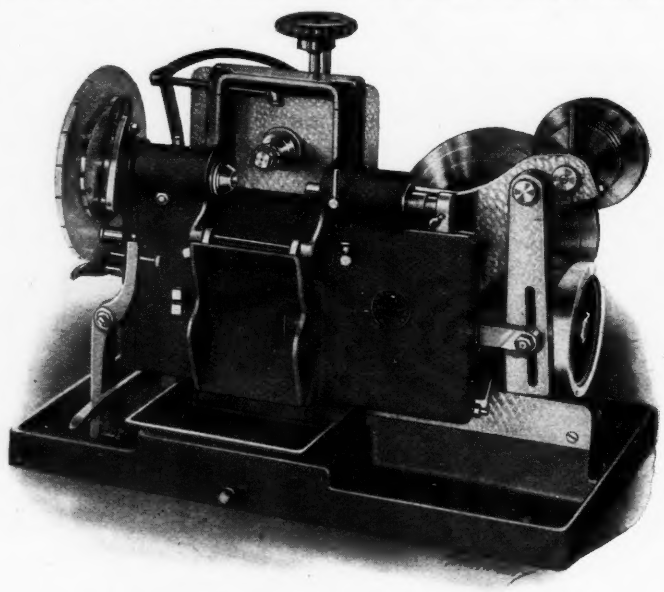
This action is automatic up to the point at which the tool reaches the end of its cut at the point of the shell. Then the operator must stop the longitudinal feed of the carriage, withdraw the tool from the cut, and return the carriage to the starting point by means of the wheel that governs hand traverse of the carriage. As the operator moves the carriage toward the headstock, slide *C* is held against stop *H* by means of weight *F* until stop *E* is reached, after which slide *C* moves with the carriage to the starting point, thus completing the cycle of the turning operation. It will be apparent that the operation of this profiling attachment is automatic, and that the only attention required from the operator is that incident to any lathe turning operation, *i. e.*, adjustment of the tool to the cut, starting and stopping the carriage feed, and returning the carriage to the starting point.

## WALTHAM GEAR-CUTTING MACHINE

Waltham Machine Works, Newton St., Waltham, Mass., have recently added to their line the 4-inch gear-cutting machine illustrated and described herewith. Sufficient power is provided for cutting 16-pitch gears. The operations of feeding the slide and indexing the work are automatic, and are continued until the machine stops upon completion of the last cut. An index is used which is 10 inches in diameter; and the indexing mechanism is so arranged that it can be easily adjusted for any even number of divisions into which the index is cut, making it possible to use one index for several different divisions, eight being the smallest number of divisions that can be obtained. These indexes are interchangeable with those used on Waltham 3-inch gear-cutting machines, and additional indexes can be furnished at any time. The use of a cutter not over 1⅜ inch in diameter is recommended, as a small cutter of this kind tends to give a smooth cut, and the machine was designed for the use of a tool of this kind working at its full capacity. The cutter-slide is lifted during the return of the work-slide, so that the indexing is done without loss of time. Alignment of the cutter to the center of the work is obtained by rotating the front bearing of the cutter-spindle, which is threaded for this purpose. The bearing should be clamped after the position of the cutter has been obtained and a gage is furnished to assist in centering the cutter.

Adequate protection is afforded to prevent chips from finding their way into the bearings, and the cutting oil or compound is carefully controlled while the chips are fed into a receptacle directly below the work-slide, from which oil is drained to a reservoir located at the back of the machine. An individual oil-pump is provided. Complete protection of the indexing mechanism, cams, and slides against damage from chips, is obtained by a plate attached to the cutter-slide and held in contact with the back side of the hood on the work-slide. A removable cover completely encloses the work and cutter when the machine is in operation; this arrangement makes the machine especially well adapted for cutting brass, as it does away with trouble due to tendency to become clogged with chips. The work-slide is driven through a worm and gear keyed to the cam-shaft, and a positive movement is given by the cam both for the cut and return, the latter being made in one-seventh revolution. With the standard cam provided, the available adjustment of the stroke is from 2 to 3 inches, but shorter cams can be furnished for cutting pinions and other short stroke work. Location of the work-slide in relation to the cutter can be adjusted laterally by turning a pinion shaft on the front of the work-slide, and the depth of cut is controlled by a graduated handwheel at the top of the cutter-slide.

A countershaft suitable for use on a wall is furnished with the machine. It is placed directly over the machine, and in order to allow for the lift of the slide, the cutter-spindle is driven by a horizontal belt from an intermediate shaft attached to the machine. This shaft has an adjustment for tightening the belt, and reversible idler pulleys are used. In connection with two-step pulleys on the countershaft and cutter-spindle, this makes possible a number of different speeds



Four-inch Gear-cutting Machine built by Waltham Machine Works

for the cutter without changing the speed of the countershaft. For general classes of work, this speed should be about 700 revolutions per minute. Four steps are provided on the worm spindle cone pulley, giving a variety of feeds. The work-spindle takes a spring chuck so that the work can be held either by this means or by special arbors suited to the needs of the particular class of work to be handled. Complete equipment of the machine includes an individual oil-pump, a countershaft, one index, one work-slide cam, and one cutter-arbor. Work-holding arbors are furnished as an extra equipment, and a cabinet base can be provided for those who do not wish to use the machine on a bench. The space occupied by this gear-cutting machine is 28 by 18 inches, and it weighs approximately 500 pounds.

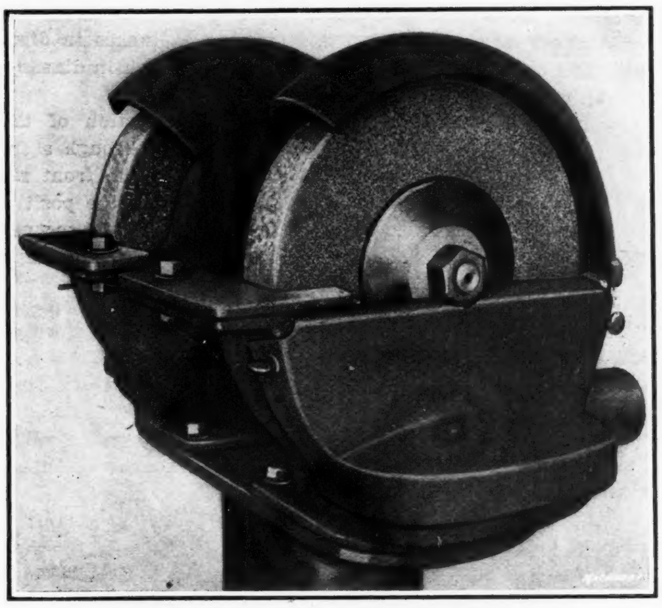
## ELLIS-SMITH POWER HACKSAW

Ellis-Smith Mfg. Co., Inc., 216 Niagara St., Buffalo, N. Y., is now manufacturing a small high-speed power hacksaw especially adapted for use in garages and repair shops. This machine is 24 inches long, 6 inches wide, stands on 10-inch legs, and has a capacity for sawing work up to 4 by 4 inches in size. The slide is furnished with large adjustable V-bearings; the saw arm takes a 9-inch blade and is driven by a crank working between the V-bearings. This design provides a compact form of construction. The saw frame is equipped with a sliding weight to provide for obtaining the desired pressure between the saw and the work. This machine is furnished with an automatic stop, and for use in plants not equipped with power a crank can be furnished for driving the machine by hand.

## FORBES & MYERS GRINDER

In the June, 1914, number of MACHINERY, a description was published of a motor-driven grinder which had just been placed on the market by Forbes & Myers, 178 Union St., Worcester, Mass. Recently this firm has modified the design of the grinder to provide connections to an exhaust system. In general design, the machine is similar to the former model; it is equipped with wheels 12 inches in diameter by 2 inches face width, and driven by a two-horsepower fully enclosed motor. The tool-rests are adjustable in two directions; the spindle is 1 inch in diameter through the wheels and is carried in ball bearings of ample size, and heavy malleable iron guards are provided over the wheels.

As previously mentioned, the new feature consists of the provision for collecting dust. Heavy particles collect in a basin under the wheels, which can be reached by removing the cover from the lower half of the wheels; finer dust is carried out through a pipe at the rear of each wheel. Even



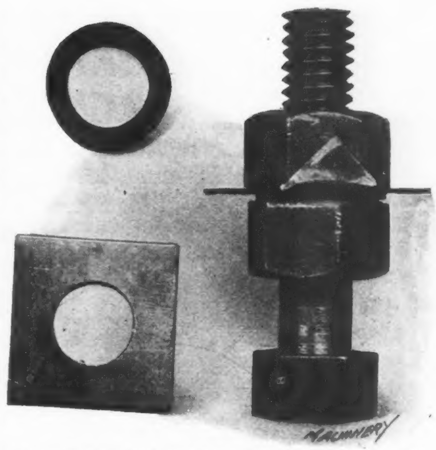
Forbes & Myers Grinder for connection to Exhaust System

when not connected to an exhaust fan, the design of this grinder is such that most of the fine dust is carried out through the pipe, due to the natural circulation of air caused by the wheels. This grinder is built in only one size, with a motor adapted for connection to circuits of two or three phase, twenty-five or sixty cycle, and of any voltage. The speed of the wheels is 1800 R.P.M when operated on sixty-cycle current, and 1500 R.P.M. when operated on twenty-five-cycle current. The grinder finds application for general work in machine shops and forge shops, and for snagging small castings in foundries. Numerous other uses can be found for this machine in grinding light work.

## "LOXON" NUT LOCK

F. R. Blair & Co., Inc., 50 Church St., New York City, are now manufacturing what are known as the "Loxon" nut locks. It is claimed that these provide as positive a lock as that furnished by a castellated nut and cotter-pin. The "Loxon" nut lock can be easily applied and locked; and it is also an easy matter to release a nut held with this device. Another advantage claimed for this nut lock is that it can be used repeatedly and is suitable for use on soft steel, cast iron, brass, bronze, aluminum, etc. The "Loxon" nut locks should not be used on hardened steel. These nut locks are made in six sizes for use on bolts 5/16, 3/8, 7/16, 1/2, 9/16, and 5/8 inch in diameter. In place of the regular square washers, special shapes can be furnished for use in counterbored holes, against shoulders, etc.

The accompanying illustration shows the method of applying "Loxon" nut locks. It will be seen that there is a square washer and a "seating ring," which come between the under side of the nut and the work. The seating ring is made of hardened steel and roughened so that the points imbed themselves in the metal, and one corner of the washer is bent up against one face of the nut to lock it in place. In the accompanying illustration the lower nut represents a casting or piece of work of any sort, while the upper one may be supposed to have been applied to a stud or machine bolt. "Loxon" nut locks are equally serviceable for locking cap-screws in place.

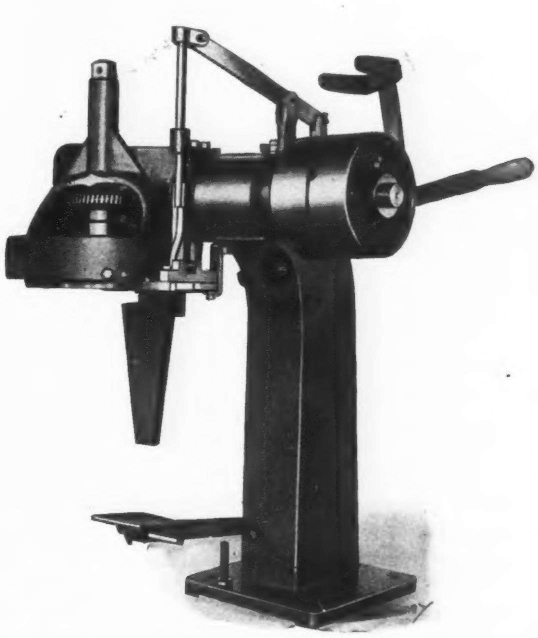


"Loxon" Nut Lock made by F. R. Blair & Co., Inc.

## REYNOLDS SCREW COUNTER

Reynolds Pattern & Machine Co., 101-103 Third Ave., Moline, Ill., has recently added to its line a machine adapted for counting and delivering a fixed number of screws into a package. The machine shown in the accompanying illustration delivers eight screws. Those who are familiar with the screw-driving machines of this company's manufacture, will see that the present equipment is of similar design in so far as the hopper and delivery chute are concerned. It has been especially developed to meet the requirements of hardware manufacturers, etc., who have occasion to pack a certain number of screws with each unit of their output, these screws being used by the purchaser in assembling the goods contained in the package.

In operation, a quantity of screws is put into the magazine or hopper, and when the operator has placed the other articles in the package into which the screws are to be delivered, the package is set in place beneath the delivery chute and the operating lever of the machine is depressed. Through suitable connections, this operates an escapement which, in turn, delivers the screws into the chute down which they pass and drop into the package placed to receive them. The machine may be set for delivering any number of screws, according to the requirements of the work, and provides a rapid method of handling work with automatic control that eliminates errors due to the carelessness of employes.



Screw Counter built by Reynolds Pattern & Machine Co.

## GRAND RAPIDS UNIVERSAL GRINDER

The machine shown in Fig. 1 is known as the Grand Rapids No. 2 universal cutter, drill and tool grinder, and has just been placed on the market by the Grand Rapids Grinding Machine Co., Grand Rapids, Mich. In working out the design of this machine, equal attention has been paid to the provision

Fig. 1. Grand Rapids No. 2 Universal Drill, Cutter and Tool Grinder

of means for grinding drills, cutters and reamers, so that all of this work is done by the machine proper and not by attachments. The spindle speed for the small cutter grinding wheel is necessarily much higher than that required for the large drill grinding wheel, so that a double spindle construction is necessary. This is taken care of by using a "Fabroil" cloth pinion on the cutter grinding spindle, which is not only noiseless at high speed, but eliminates other troubles incident to the use of metal gears, and the "Fabroil" gear is as strong as the cast-iron gear with which it operates. Both spindles are carried in large bronze bearings, which are ring-oiled and

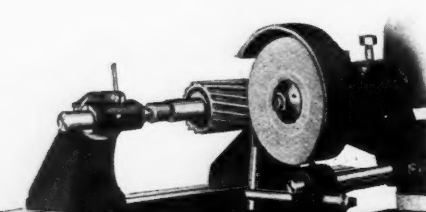


Fig. 2. Grinding a Milling Cutter held on Centers

easily adjusted for either radial wear or end play. The spindles are made of crucible steel accurately ground to size.

For drill grinding, the holder has a capacity for drills from 1/8 inch to 2 1/2 inches in diameter, and what is more important, one standard holder provides for obtaining any desired angle of point and any desired clearance; two-, three-, or four-lip drills of any size or type of shank may be ground, even though the shank is larger than the diameter of the drill. A wheel truing device is provided for truing the grinding face of the wheel, so that it may be kept accurate. The cutter grinding part of the machine will handle any cutter, reamer, or tool that any universal grinder will handle, provided it comes within the capacity of the machine, which is as follows: diameter of work held between centers, 9 1/2 inches; length of

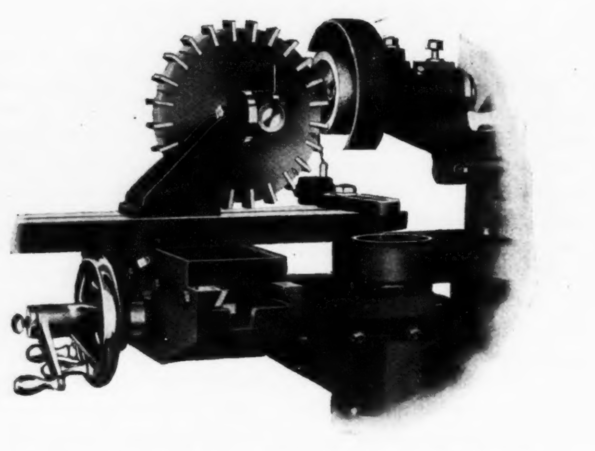


Fig. 3. Sharpening Faces of Inserted-tooth Milling Cutter

work held between centers, 20 inches; longitudinal movement, 15 inches; transverse movement, 7 inches; vertical movement, 6 3/4 inches; capacity for face mills, up to 12 inches in diameter; and capacity for internal work, from 5/8 inch in diameter and up to 3 1/4 inches in depth.

Points of particular interest in the construction of this machine are as follows: The table will swing through a full 360 degrees, and the same two screws—one at the front and one at the back of the sub-table—that lock it in the position to which it has been swiveled also lock the table securely down upon the sub-table. A scale reading to 1/16 inch taper

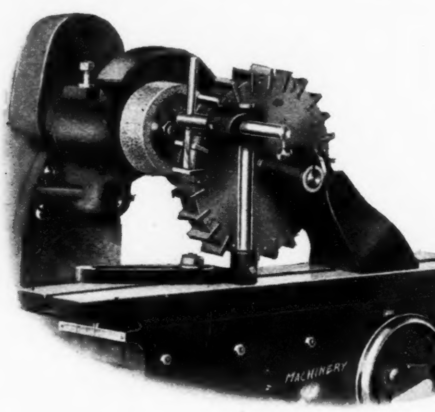


Fig. 4. Sharpening Sides of Teeth of Cutter shown in Fig. 3

per foot is provided for making settings of the machine for taper grinding operations. An auxiliary lever is furnished that can be instantly mounted on the longitudinal movement handwheel by simply slipping it over the wheel, and tightening it up by means of a thumb-screw, thus providing a lever action that is convenient for many classes of grinding. The headstock is provided with tongue slots in both directions, so that it can be mounted either in line with or across the table; and the vise is also carried on the headstock, so that it can be mounted in either position. This vise has a swivel action of its own, so that it presents the work to the wheel in either

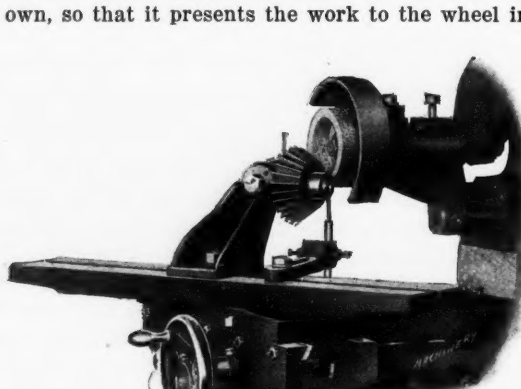


Fig. 5. Table set over for grinding Tapered Cutter

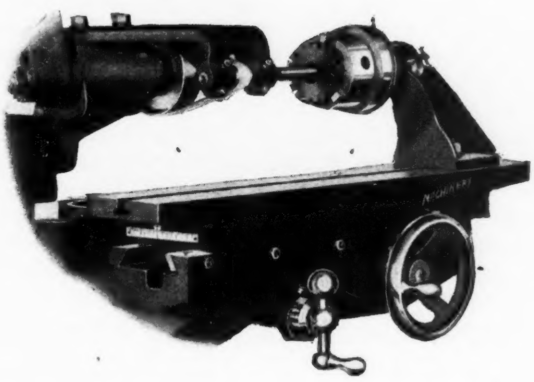


Fig. 6. Performance of Internal Grinding Operation

horizontal, vertical or angular position. Both vertical and cross-feed screws operate in bronze nuts that provide generous bearings for the screws, which have dials reading to 0.001 inch.

## BICKETT MILLING AND PROFILING MACHINE

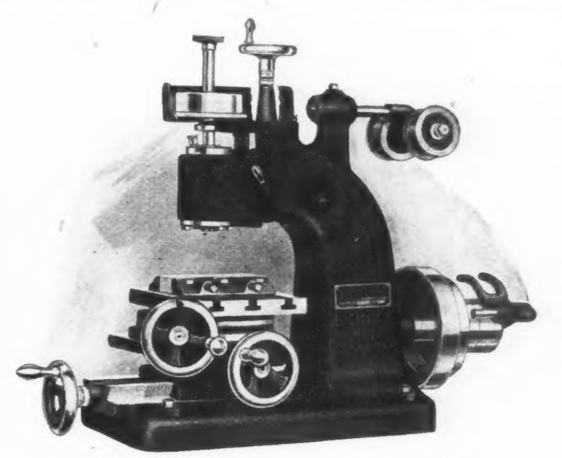
In working out the design of a No. 0 vertical milling and profiling machine which has recently been placed on the market by the Bickett Machine & Mfg. Co., 1118 Richmond St., Cincinnati, Ohio, a departure has been made from the practice of using an adjustable knee, all adjustment being provided in the spindle head of the machine. It is claimed that this provides a more rigid table support, thus reducing vibration to a minimum and maintaining alignment at all times. This machine is especially designed for operation at high speed, and may be driven at 2500 revolutions per minute. It is adapted for such work as die-sinking, letter cutting, cam milling, splining, etc., and finds application in factories engaged in the manufacture of sewing machines, typewriters, electrical and scientific instruments, firearms, adding machines, etc.

The use of radial-thrust bearings adapts this machine for operation at the high speeds referred to, and also enables advantage to be taken of a high transmission efficiency by reducing friction losses to a minimum. These ball bearings are self-oiling and will run for a long time without requiring attention; their use has been the means of practically eliminating trouble from hot bearings. If desired, the machine can be furnished with a lever feed attachment in place of the handwheel and elevating screw. This attachment is convenient when rapid vertical adjustment is required, as in certain classes of profiling. In working out the design, attention has been paid to providing means for convenient operation.

The spindle is made of crucible steel, accurately ground to size. It is fitted with a No. 3 Hardinge collet, which is held by a draw-in attachment operated from the top of the spindle. The spindle head is gibbed to the column of the machine, and the vertical adjustment is two inches, obtained by means of an elevating screw at the rear of the spindle. Two changes of speed are provided, and as mentioned, the machine may be safely driven at 2500 revolutions per minute under continuous operation. The spindle pulley is 1¼ inch wide by 4 inches in diameter; it is flanged at the bottom and provided with a belt guard. The intermediate pulleys are 2½ inches in diameter and are flanged on both sides. The two-step cone pulley has steps 8 and 6 inches in diameter; and the tight and loose pulleys are 3½ inches in diameter by 1¾ inch face width.

A handy belt shifter is provided for starting and stopping the machine. The table is 7 by 10 inches in size and has three ½-inch T-slots machined in it. This table may be rotated by means of an Acme-thread screw, which is carefully fitted to a large worm-wheel. The worm feed can be easily engaged or disengaged and is provided with means of compensation for wear. The longitudinal, transverse and vertical feed-screws are provided with adjustable dials graduated to read to 0.001 inch, and all screws have Acme threads.

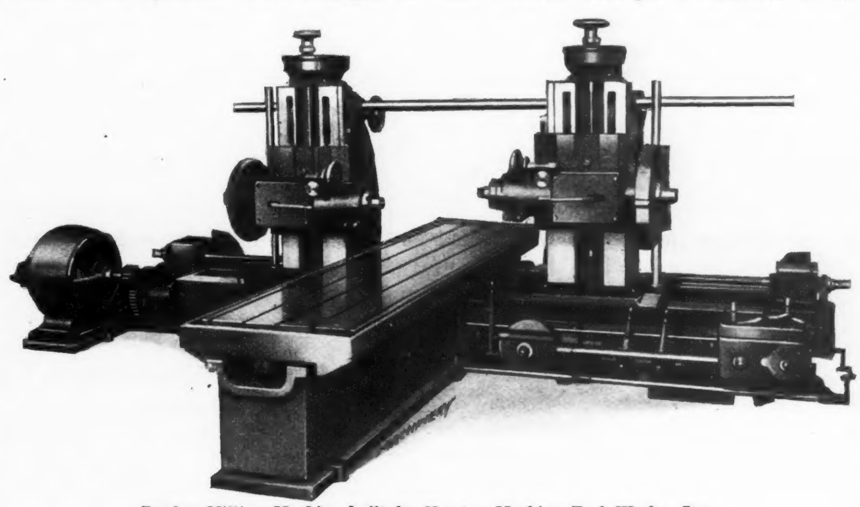
The equipment furnished with this machine includes the following: one toolmaker's vise with jaws 6 inches wide by 1 inch high, with a maximum opening of 6 inches; one No. 3 Hardinge collet; one draw-in attachment; and the necessary wrenches for making all adjustments. A pedestal 26½ inches high may be furnished as a special equipment. The principal dimensions of the machine are as follows: total height of machine without pedestal, 26½ inches; width of base, 11 inches; length of base, 20 inches; distance from top of rotary table to spindle nose, 4¼ inches; maximum longitudinal feed, 6 inches; maximum transverse feed, 5 inches; maximum vertical feed, 2 inches; and weight of machine, 200 pounds.



Bickett No. 0 Vertical Milling and Profiling Machine

## NEWTON DUPLEX MILLING MACHINE

One of the latest additions to the line of machinery built by the Newton Machine Tool Works, Inc., Philadelphia, Pa., is the duplex milling machine illustrated and described herewith. A feature of its design is the exceptional provision made for power control; it will be noted that the spindle saddles move vertically on the uprights, while these uprights move horizontally on the bed. Both saddles and uprights have reversing feed and reversing fast power traverse; provision is also made for independent or simultaneous adjustment of the spindle saddles, and of the uprights. For the spindle saddles, the vertical feed per revolution of the spindle is from 0.012 to 0.134 inch, and the same feed in inches per minute covers a range of from 0.068 to 7.40. Reversing fast traverse for the spindle saddles covers a range of from 6.10 to 63.4 inches per minute. The feeds of the uprights cover a range of from 0.011 to 0.113 inch per revolution of the spindle, or from 0.059 inch to 6.360 inches per minute. Reversing fast traverse for the uprights covers a



Duplex Milling Machine built by Newton Machine Tool Works, Inc.

range of from 5.25 to 54.50 inches per minute. The available range of spindle speeds is from 5.4 to 55.2 revolutions per minute.

This machine is driven by a Fort Wayne Electric Co.'s 230-volt, twenty-horsepower electric motor running at from 300 to 900 revolutions per minute. It is provided with a work-table which has square lock bearings on the base with overlapping gibs. Drive is provided through an angular rack and worm pinion, with hand adjustment, and there are nine changes of sliding gear feed provided by a gear-box, in which the gears run in oil. Available feeds for the work-table are from 0.041 to 0.427 inch per revolution of the spindle, or from 0.222 inch to 23.93 inches per minute. Reversing fast traverse for the table covers a range of from 19.7 inches to 17 feet per minute. The dimensions of the table are as follows: width over finished surface, 42 inches; length over all, 14 feet; and available length for milling operations, 12 feet, 6 inches. The work-table can be arranged to mill to greater lengths when the requirements of the work to be handled on the machine make such a provision a matter of necessity.

Attention has already been called to the fact that the spindle saddles are adjustable vertically on the uprights, and that these uprights are provided with means for making horizontal adjustment on the bed. Each spindle is driven through a worm and worm-wheel encased to provide for flooded lubrication, and the drive for each spindle is independently clutched at the inside of the driving worm-wheel sleeve. The spindle saddles are counterweighted, and provision is made for simultaneous or independent vertical hand adjustment; a similar provision is made for the reversing vertical feed and reversing fast power traverse. The saddles have narrow-guide alignment control bearings on the uprights, and provision for rigidly bolting in any desired position. The uprights have independent and simultaneous horizontal hand adjustment, and reversing fast power traverse, with provision for rigidly bolting in any desired position. Both the saddles and uprights are fitted with taper shoes, and the saddle elevating and upright adjusting screws have bearings at each end to insure their operation under tension. The spindles can rotate independently or in unison. Each spindle sleeve is furnished with independent hand adjustment up to 6 inches, and measurement of the spindle sleeve and vertical saddle adjustment is provided through conveniently arranged scales.

The principal dimensions of the spindle and allied members are as follows: distance from face of uprights to center of spindles, 6¾ inches; distance from center of spindles to table, 2 inches to 35 inches; distance between ends of spindles, 12 inches to 90 inches; diameter of spindle in driving worm sleeve, 4 inches; diameter of spindle at large end of taper, 6 9/16 inches; diameter of spindle in sleeve, 4 3/8 inches; diameter (outside) spindle flange, 9 inches; and approximate outside diameter of spindle driving worm-wheel, 27 inches. The spindles are bored in the nose to accommodate a straight plug 3 inches in diameter, and are arranged to drive cutters by means of face keys 1¼ inch wide. If desired, the spindles can be bored taper up to No. 6 Morse and drilled through to accommodate a cutter retaining bolt. The machine is adapted for using cutters up to 16 inches in diameter when working on cast iron.

## FOSTER UNIVERSAL TURRET LATHE

*It will be seen that this universal turret lathe is adapted for performing both chucking operations and operations on bar stock. Single-pulley drive and a geared head make it an easy matter to employ either belt drive or motor drive. Two tool-carrying units are provided, one of which is a slide carrying a hollow hexagon turret, and the other a cross-slide with a square turret at the front and provision for securing special tool-holders at the back. Details of the mechanism are fully explained in the following article.*

The Type I-B universal turret lathe shown in the accompanying illustrations is just being put on the market by the Foster Machine Co., Beardsley Ave. and Ward St., Elkhart, Ind. The first machine has been in successful operation in this company's shop since the early part of December, and a complete set of jigs and fixtures for efficient and economical manufacturing of this machine is now in the course of construction. The machine, which is of the universal turret lathe type and capable of handling both bar and chucking work with equal facility, has been designed by Oskar Kylin, now chief engineer of the Foster Machine Co. The machine, as shown by Figs. 1, 2 and 3, is of the geared head type with two tool-carrying units, one of which is equipped with a hollow hexagon type of turret and the other with a cross-slide. The latter extends across the ways of the bed and carries on the front end a square turret adapted for holding forged cutters. The rear end forms a table and has several tapped holes to provide for mounting a variety of tool-holders. The illustrations show a machine equipped with draw-back automatic chuck for bar work, but this can be replaced by a three-jaw geared scroll chuck for chucking work.

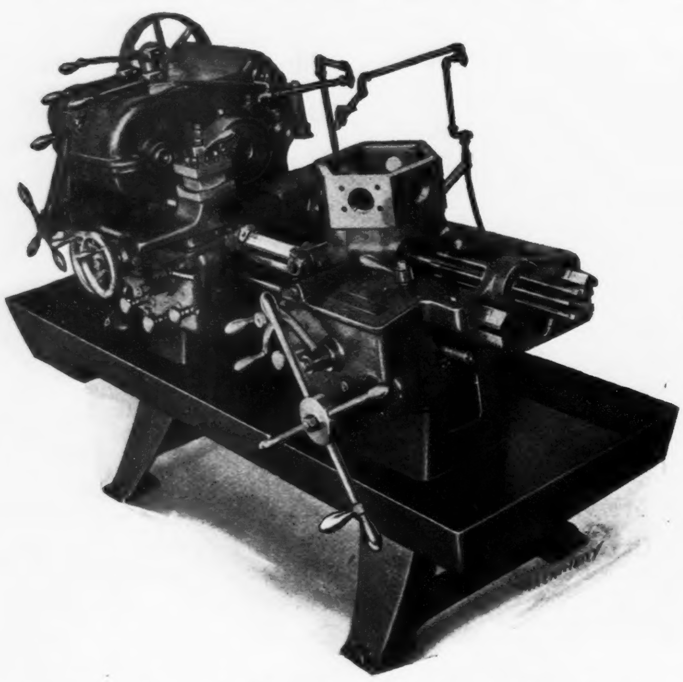


Fig. 1. Foster Type I-B Universal Turret Lathe with Two Tool-carrying Units

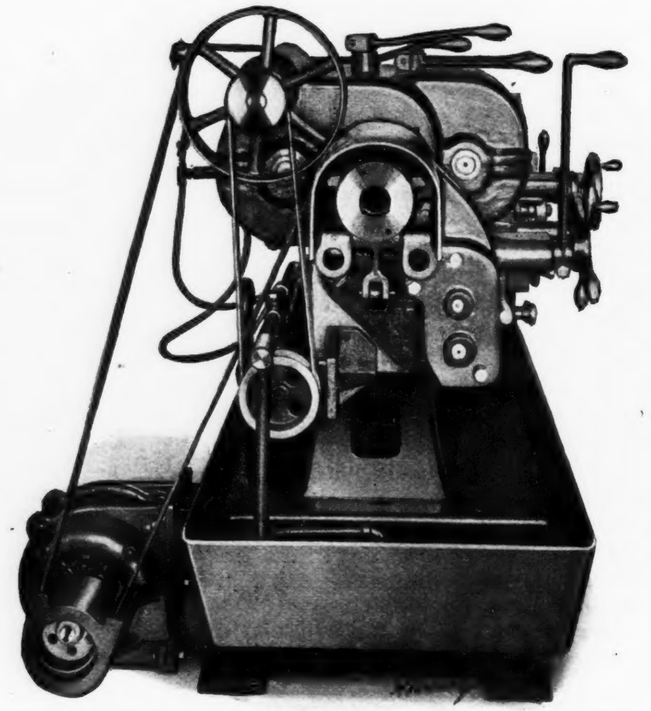


Fig. 2. End View of Foster Universal Turret Lathe, showing Motor Drive

### All-geared Head

Fig. 2 shows a machine arranged for motor drive, but it can also be driven by means of a plain tight and loose pulley

countershaft mounted in the ceiling. Fig. 4 shows a view of the geared train in the head, the upper guard being removed to show the mechanism. As seen in this illustration, the pulley shaft is mounted in phosphor-bronze boxes and carries a wide faced pinion, which on one side engages the large gear underneath it for the forward driving of the spindle, and on the other side a reversing idler for the reverse motion of the spindle. The friction driving member, which is mounted inside and between these two gears, is of powerful construction and operated by means of the long lever seen in Fig. 4. Twelve speed changes for the spindle in either direction are obtainable by three clusters of sliding gears, operated by levers mounted on the top of the head casting, as shown plainly in Fig. 1. All sliding gears and gears engaged by them are heat-treated and hardened. The teeth are of the Fellows standard stub tooth form, with a 20-degree pressure angle which insures greater strength, less wear and quieter running. This gear tooth system is used for all the gears throughout the machine.


Fig. 5. Range of Spindle Speeds and Directions for making Changes

An important feature of the design is the oiling system used for the automatic lubrication of all gears and bearings throughout the entire head. The gears run in a bath of oil, and the splash is caught by a system of overhead ribs and conducted back into the main cavity of the head. The belt, whether driven by means of an overhead countershaft or by an individual motor as shown in Fig. 3, is capable of delivering to the pulley about six horsepower. This is somewhat in excess of the heaviest requirements of the machine, even when several cuts are taken simultaneously, which is a frequent occurrence on a machine of this type and represents a time-saving feature. However, the friction clutch in the gears in the head is proportioned to stand a load in excess of the greatest amount of power that will be delivered by the belt.

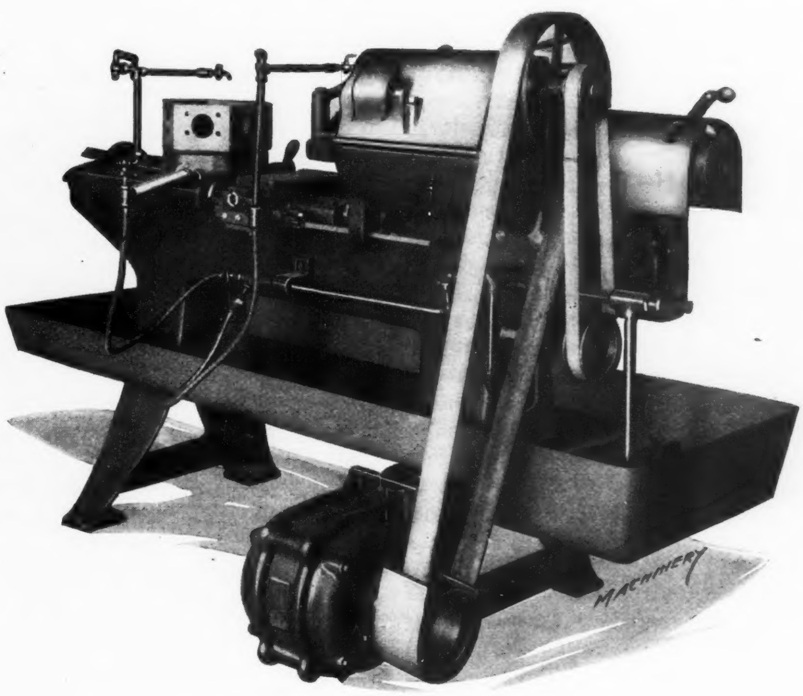



Fig. 3. Rear View of Foster Universal Turret Lathe

The spindle is made of a forging of high-carbon machine steel and is journaled in bronze boxes of exceptional length, in spite of the fact that the wear is reduced to a minimum by means of the automatic flooded lubrication. The twelve spindle speeds range, as seen in Fig. 5, from 20 to 480 revolutions per minute, and these are arranged in as perfect geometrical progression as is obtainable with geared trains. This range is wide enough to provide the correct cutting speed for work ranging from hard cast iron of the largest diameter that can be carried in the three-jaw scroll chuck down to and including the smallest diameter bar which it is practicable to turn in a machine of this size.

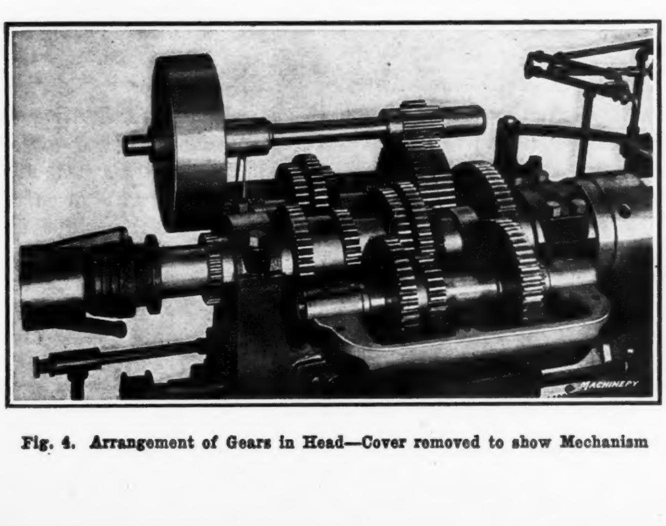



Fig. 4. Arrangement of Gears in Head—Cover removed to show Mechanism

### Gear-boxes

The gear-box, which is mounted on the end of the bed and shown in Fig. 6, is designed to carry and enclose the gears for driving the feed-rod which actuates the various feed movements for the tool-carrying units. In this connection, it is timely to call attention to the location of the feed changing mechanism for the twelve changes of feed. The gears and mechanisms for this purpose are located in the aprons of the tool carriages with the exception of one gear-shift located in the gear-box, the gears in this shift being heat-treated and hardened sliding gears. This sliding gear cluster is operated by means of a plunger shown in Fig. 1, which carries a knob for convenience of operation. In addition to the gears, the gear-box carries a forked lever for operating the automatic chuck and also supports the bars that are employed for the bar feed.

### Cross-slide and Carriage with Carriage Apron

The feed chart, which is illustrated separately in Fig. 7, shows the unusually wide feed range which covers changes from 0.0016 to 0.100 inch per revolution of the spindle, and also shows the method of obtaining these changes. The feed changes obtainable are sufficient to provide the proper feed for any work from soft cast iron to wide forming in steel and also for the varying depths of cuts which necessitate varying feeds for maximum production. As already mentioned, the feed mechanism is located in the apron and changes are obtainable by means of sliding gears operated by plungers. The sliding gear clusters are made of chrome-nickel steel and heat-treated. Thus the maximum strength and wearing quality is obtained in connection with compactness and lightness of the apron unit. The driving pinion which engages the rack mounted on the front side of the bed is also made of chrome-nickel steel which is heat-treated. The gear train is driven from the feed-rod by means of the worm and gear as shown plainly in Fig. 8, which shows the apron dismounted from the machine.

Attention is called to the automatic drop-out friction which engages and disengages the longitudinal feed movements. This is operated by means of the six screw stops mounted in a revolvable spool as seen in Fig. 8. When one of these stop-screws, as the carriage is moving longitudinally forward on the bed, abuts against the adjustable stop-rod, it causes a longi-

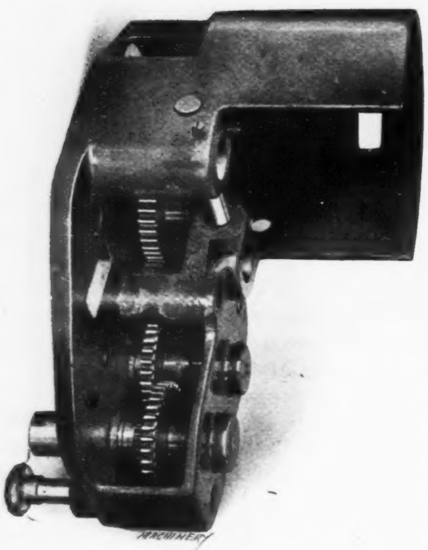



Fig. 6. Gear-box for Gears employed to drive Feed-rod

tudinal movement of the stop-spool, which releases a catch and causes the horizontal lever to drop and thus release the feed friction. The advantages of this design are quick operation and assurance that the drop-out action will always occur at one and the same point. The design of the friction release for the cross movements of the slide is similar to that of the longitudinal friction release. However, this is not automatic, but hand-operated by means of the short vertical lever. The reverse for the longitudinal and cross motions is also located in the apron and is obtainable by means of sliding gears.

For the purpose of duplicating diameters, there is mounted on the front end of the cross-feed screw, a dial of large diameter, on which are mounted a number of clips which are brought to register with a zero mark on the cross-slide. Very close duplication of work can thus be obtained. On the cross-slide is mounted a square turret for carrying four forged cutters. This turret is so designed that the vertical lock-bolt is located underneath that corner where the cutting action almost invariably takes place, and is operated by a handle mounted on the top of the turret. Forward movement of this lever, when the lock-bolt is engaged, binds the turret rigidly to its seat. The rear of the cross-slide forms a table and has several tapped holes in it for the purpose of mounting a variety of standard and special tool-blocks or tool-holders. This feature is especially valuable when manufacturing parts in large lots, as it provides means for mounting specially designed tools and also for holding forming tools too wide to be mounted in the square turret.

A clamp handle is provided on the top of the carriage for clamping the carriage to the bed. Another feature worthy of special mention, which is valuable in connection with thread cutting, is the mechanism at the front end of the cross-slide that enables the tool to be withdrawn the necessary amount and at the proper time reset and feed the proper amount for taking the next cut. This mechanism consists of a disk mounted loosely on the cross-feed screw, to be turned in the reverse direction and then again brought back to a starting point, at which point the bar strikes the end of the semi-annular groove and thus registers the former position of the cross-slide. The disk, which is held at the cross-slide by means of a brass shoe and set-screw, can then be slipped past this point each time the proper amount for the feeding of the next cut of the thread cutting tool.

### Hexagon Turret and Saddle with Saddle Apron

The turret is of the hollow hexagon type and has an unusually large bearing on the saddle. The vertical lock-bolt, mounted as close as possible to the cutting tool, is withdrawn by means of the lever, and this lever also operates the binding mechanism for the turret. The first part of the upward movement of the lever toward the left unbinds the turret from its seat and further movement withdraws the lock-bolt and leaves the turret free to be indexed by hand. This is an economical and quick way of indexing a turret on this type and size of machine. The seven stop-screws, one of which is for the corner stock stop, which are held in a revolvable spool carried by the saddle, are geared to the turret and thus indexed with it. Forward movement of the saddle causes a stop to butt against a stop-block mounted between the ways of the bed. A slight forward movement of the saddle causes a longitudinal movement in the stop and stop-spool, which is transmitted to a catch that is thus released and causes the feed lever to drop. The feed friction is thereby released and forward movement of the saddle arrested. The design is similar to that of the saddle apron which has already been described. The feed changes obtainable in this unit are the same as those for the cross-slide unit, and the feed changes are the same as shown in Fig. 7.

| FEEDS PER REVOLUTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | .0016 | .0027 | .0047 | .0063 | .0083 | .011 | .014 | .019 | .025 | .033 | .056 | .100 |
| KNOB D | IN | IN | IN | OUT | IN | OUT | IN | OUT | IN | OUT | OUT | OUT |
| KNOB E | OUT | IN | IN | IN | OUT | IN | OUT | IN | OUT | OUT | OUT | OUT |
| KNOB F | CENTER | OUT | IN | CENTER | CENTER | OUT | OUT | IN | IN | CENTER | OUT | IN |

MACHINERY

Fig. 7. Range of Feeds per Revolution and Directions for making Changes

### Design of the Bed

As plainly seen in Figs. 1, 2 and 3, the head is cast integral with the bed. The comparatively short span between the front and rear legs made it possible to design a bed of extraordinary rigidity without the use of an undue amount of metal. The front and rear walls of the bed are connected by a number of heavy ribs, thereby preventing distortion of any individual section of the bed by distributing the strain throughout the entire bed section. The carriage ways are of the V-type and of very liberal dimensions. This makes the unit pressure on the ways caused by the tool carriages very low and reduces wear.

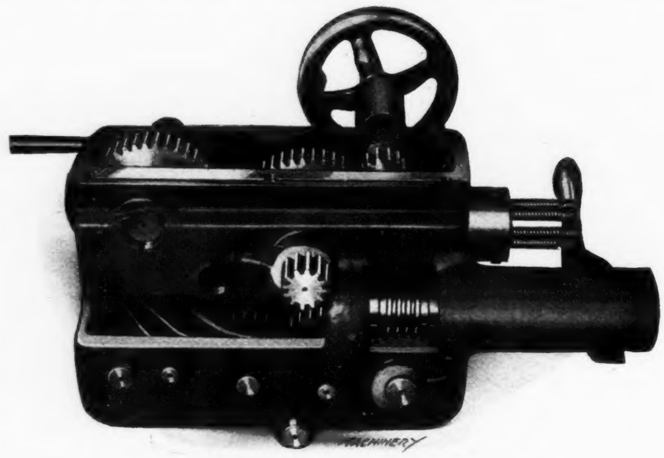



Fig. 8. Rear View of Apron, showing Mechanism for making Feed Changes

### Oil Pump and Piping

Figs. 2 and 3 show the method and system used for supplying the cutting tools with coolant. The oil-pump is driven by belt from the main pulley shaft and is mounted on the rear side of the gear-box. The coolant is drawn from the well in the steel pan and delivered by means of the pump through piping and flexible tubes. Each tool-carrying unit has its separate pipe fitted with swinging joints and stop-cocks for adjusting the position and flow of the stream of coolant. In addition, coolant can also be supplied through the hollow hexagon turret, for oil-tube drills and similar cutting tools requiring this device. Special attention is called to the arrangement of the piping enclosed by the oil-pump, making priming of the pump unnecessary.

### Motor Drive

Figs. 2 and 3 show the machine arranged for individual motor drive with the General Electric five-horsepower motor mounted on the rear of the front leg. This makes a neat and compact arrangement; but this arrangement is special inasmuch as the machine is regularly equipped with the overhead tight and loose pulley countershafts driven from the lineshaft.

Tool and Surface Grinder built by Peter J. Metz Machine Works

## METZ TOOL AND SURFACE GRINDER

Peter J. Metz Machine Works, 560-562 W. Washington St., Chicago, Ill., are now manufacturing a tool and surface grinder shown in the illustration accompanying this description. It is intended for general shop and tool-room service, and has been designed for grinding flat surfaces such as blanking, stamping and piercing dies, punches, lathe and planer tools, and similar work. The spindle is made of high-carbon steel and runs in split conical boxes made of anti-friction phosphor-bronze and provided with adjusting nuts. This construction permits of easy compensation for wear. A graduated dial is provided on the vertical feed-screw, the graduations reading to 0.001 inch, but finer adjustment can be readily obtained when such degree of accuracy is required. Traverse movement is obtained by a screw feed operated by a handwheel.

Longitudinal movement of the table is obtained by a rack and pinion, with a handwheel located at the front of the machine, which is found convenient when grinding dies, gages, and tools. Under one wheel there is an adjustable tool-rest, and under the other wheel there is a short surface table having a 5/8-inch milled T-slot at the center. All bearing surfaces are protected from dust and dirt, and the ways are hand-scraped to a perfect bearing. Provision has been made for oiling all bearings that are subject to wear, and the table is provided with a dovetail slide with gibs for taking up wear. Attention is called to the fact that all operating handles are located at the front of the machine where they are convenient for the operator to reach at all times. This machine is furnished complete with two grinding wheels, a countershaft, wheel guards, and tool-rests.

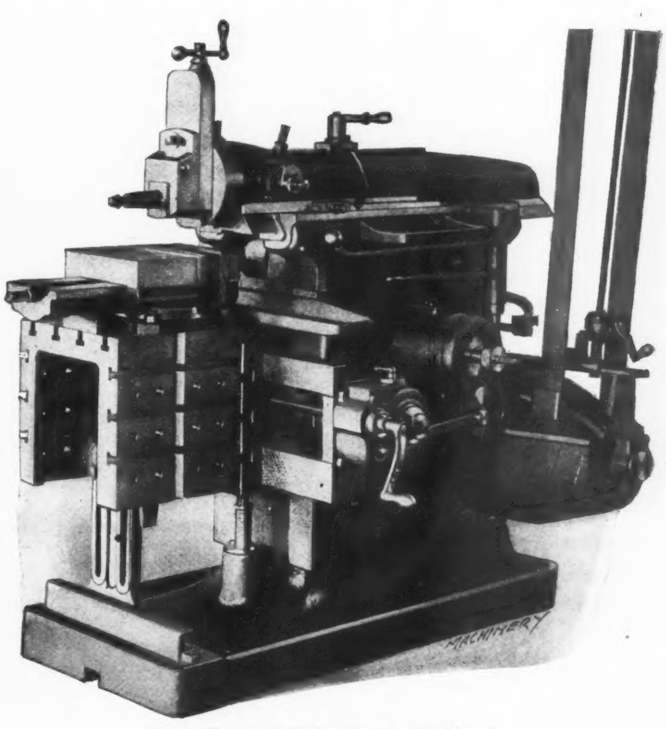
The principal dimensions are as follows: size of grinding wheels, 8 inches in diameter by 1 inch face width; diameter of spindle between flanges, 3/4 inch; distance from center to center of wheels, 19 1/2 inches; size of working surface of table, 9 by 24 inches; longitudinal movement, 24 inches; traverse adjustment, 9 inches; speed of countershaft, 500 revolutions per minute; size of pulley, 4 inches in diameter by 2 3/4 inches face width; size of driving pulley countershaft, 12 by 3 1/4 inches; size of tight and loose pulleys on countershaft, 6 inches in diameter by 4 inches face width; height from floor to center of spindle, 40 1/2 inches; length of spindle bearing, 4 3/8 inches; floor space occupied, 18 by 22 1/2 inches; and weight of machine, 550 pounds.

## HENDEY CRANK SHAPER

The 20-inch crank shaper which forms the subject of the following description, is a recent addition to the product of the Hendey Machine Co., Torrington, Conn. It will be seen that the frame and base are cast integral, and an oil pan is provided in the base to catch all drip from the bearings and keep the floor clean. The bull gear hub is cast solid and is liberally proportioned to take all strain in the drive when the machine is at work. The crankpin is hardened and ground, and the crankpin block is also hardened, ground and bushed with a cast-iron sleeve for the crankpin bearing. The ways for the ram have an included angle of fifty degrees, and the gib for the ram is combined with the cap in a single casting, making a very rigid construction and at the same time allowing for ample adjustment in a horizontal direction. The ram has a bearing in the frame 11 1/4 by 34 inches, and the ram casting is braced to provide the necessary rigidity for taking heavy cuts. It is possible to set the ram in any position while the machine is either working or at rest, the length of the stroke obtained for any position being shown by an index.

The cross-feed mechanism is operated entirely at the end of the cross-rail in all its adjustments, and a dial and indicator control the amount of feed, which can be varied while the machine is in motion. It is possible to start, stop or reverse the feed while the machine is running by means of a ball lever at the top of the case. The feed is operated only on the reverse stroke. A quick and positive method of binding the tool-head swivel to the head of the ram is furnished by a single screw. Power down feed is optional, and the down-feed screw has a micrometer dial reading to 0.001 inch. The driving cone has four steps, and the shaft has an outboard bearing in the end of the casting that forms a guard for the belt. An expanding friction cone clutch drive of large diameter engages with a cone operated by a long horizontal lever at the side of the frame. This shaper is back-geared and this, together with the four-step cone pulley, provides eight changes of speed. A belt-shifting mechanism is furnished as part of the regular equipment, on which cams are arranged to move the shifters alternately and the belt can be changed much quicker than by hand.

When so desired, the machine may be arranged for individual motor drive, in which case an adjustable speed motor is employed with connection to the power shaft by means of a slight chain drive. The motor should develop about five horsepower and run at from 400 to 1200 revolutions per minute, although a slightly higher speed range can be employed. A constant-speed motor and gear-box can also be employed in




Crank Shaper built by Hendey Machine Co.

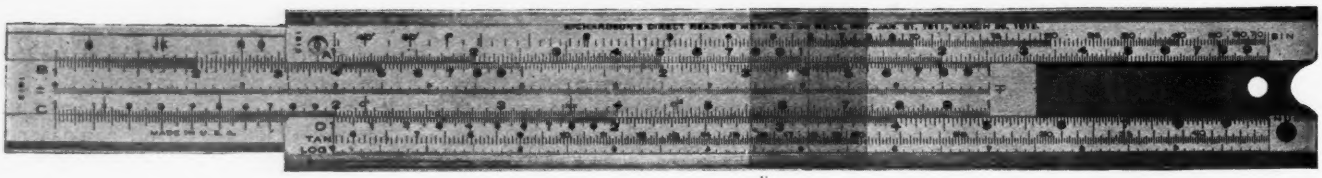


Fig. 1. Richardson "Direct-reading" Slide-rule with All Scales exposed so they can be seen

place of the equipment referred to. The cross-rail is clamped to the column with a square lock and the elevating screw is telescopic. An adjustable bottom support is provided for the table which slides on a channel-shaped track serving to protect it from chips and dirt that would throw the table out of alignment. The vise has a graduated base that is held down by four bolts, and this base also acts as a clamp to hold the vise firmly down upon the table. A boss is cast on the under side of the vise, which supports the vise ways, and at the same time ties these ways together to provide additional stiffness. The thrust of the screw which actuates the sliding vise jaw is taken at the head end of the vise casting.

The principal dimensions of this machine are as follows: actual stroke, 20¾ inches; horizontal travel of table, 24½ inches; vertical travel of table, 15 inches; minimum distance from ram to table, 4 inches; size of top of table, 16 by 20 inches; size of side of table, 16¼ by 15 inches; range of power cross-feed, 0.008 to 0.200 inch; size of ram bearing in frame, 11¼ by 34 inches; travel of head slide, 7½ inches; power feed of head slide, 0.005 to 0.060 inch; opening of vise, 13 inches; size of vise jaws, 12 by 2⅞ inches; keyseating capacity, 3½ inches; toolpost opening for tools, ⅞ by 1¾ inch; range of strokes per minute, from 8 to 115; floor space occupied, 54 by 92 inches; and net weight of machine, 4100 pounds.

## RICHARDSON SLIDE-RULES

*The two rules described in this article are known as a "direct-reading" slide-rule and a "merchant's" slide-rule, respectively. The former has the usual A, B, C and D scales, and scales for handling problems involving the use of trigonometric functions, logarithms of numbers, log functions of angles, and commonly used engineering constants. The merchant's slide-rule is a simplified rule with scales for performing the usual operations of multiplication and division, and special scales for the solution of problems in percentage and interest.*

George W. Richardson, 4212 W. 24th Place, Chicago, Ill., is now manufacturing two slide-rules which form the subject of the following description. One of these is known as a "direct-reading" slide-rule, and the other is termed a "merchant's" slide-rule. Both are made entirely of metal with the scales and numerals marked in black and red on a white background. An advantage of the metal construction is that there is no tendency for the slide to bind during damp weather.

### Richardson Direct-reading Slide-rule

Reference to Fig. 1, which shows the Richardson direct-reading slide-rule, will make it apparent to those familiar with the Mannheim slide-rule scales that the Richardson rule is provided with the standard A, B, C and D scales. With these scales are performed problems in multiplication, division, the extraction of square roots and cube roots, etc., with which all users of slide-rules are familiar.

So far as we know, Mr. Richardson is the first to graduate a special logarithmic slide-rule scale for problems in addition and subtraction. On the slide between the B and C scales, it will be seen that there is graduated a logarithmic scale reading 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, and below the D scale (and also below the scale marked "Tan") there is graduated a similar logarithmic scale. Suppose it is required to add together 12, 16 and 14. The method of procedure is as follows: Place the cross-line on the runner over 12 on the lower logarithmic scale and bring the left-hand index of the upper logarithmic scale under the cross-line. Next move the runner to the right until the cross-line comes over 16 on the upper logarithmic scale, and read the sum of these two numbers, 28, under the cross-line on the lower logarithmic scale. Next move the slide to the right until the left-hand index again comes under the cross-line on the runner; then move the runner over until 14 on the upper logarithmic scale comes under the cross-line, and read the sum of 28 and 14, 42, on the lower logarithmic scale. Problems in subtraction are performed by reversing this practice.

Problems involving the use of logarithms may be handled direct upon this slide-rule. If a number is known and it is desired to find the logarithm of that number, the method of procedure is to move the runner along so that the number whose logarithm is desired lies under the cross-line on the runner. Then directly below this cross-line on the logarithmic scale will be found the mantissa of the desired logarithm. The characteristic of the logarithm is determined by inspection, according to the usual method. Conversely, knowing the logarithm and desiring to obtain the number corresponding to that logarithm, the runner is moved out to the logarithm, and the number read on the D scale. In this way, all problems involving the use of logarithms can be handled without the use of tables.

Trigonometric problems can also be handled on the Richardson direct-reading slide-rule. At the top of the rule, over the A scale, will be seen a scale graduated 40 minutes, 50 minutes, 1 degree, 70 degrees, and to the right of this scale appears the word "Sin." When an angle is known and it is desired to obtain the sine of that angle, the runner is moved along so that the cross-line lies over the angle; the desired sine of that angle is then read on the A scale. For instance, the sine of 30 degrees is seen to be 0.5. Knowing the value of the sine, the corresponding angle may be obtained by reversing this process.

Below the D scale there is a similar degree scale with the word "Tan" marked at the left. In the present case, however, it will be seen that the scale starts with 6 degrees and runs up to 45 degrees. The reason for this is that up to 6 degrees the tangent of an angle is the same as the sine of that angle, so that for obtaining the tangents of angles less than 6 degrees the sine scale may be employed. For angles from 6 to 45 degrees, tangents are obtained in the same way that has already been explained for the sine scale, in the case of tangents use being made of the "Tan" scale and the D scale. Reversing this process enables one to obtain the value of the angle from the known value of the tangent. From the relation between the sine and cosine and the tangent and cotangent of an angle, cosines and cotangents may be obtained from the sine scale and tangent scale, respectively. These scales also provide for operating with logarithms of trigonometric functions.

To facilitate the handling of many problems in engineering,

Fig. 2. Richardson's "Merchant's" Slide-rule with Special Provision for solving Commercial Problems

the graduations of the B and C scales on the slide have been extended as partially shown by the portion of the slide extending to the left, so that provision is made for graduating constants on the space at each side of these scales. For instance, take the case of problems involving the use of data expressed in meters where it is desired to obtain results expressed in inches. At the upper left-hand corner of the rule opposite the end of the A scale (and at the lower right-hand corner opposite the D scale) there are holes which are known as "key holes." Taking the case of a problem involving the use of meters, the slide is run along until the letter *Q* appears in the key hole. We are then ready to proceed with our problem. Suppose, for the case of simplicity, that it is desired to determine the number of inches in 4.5 meters. The runner is moved along the A scale until the cross-line lies over 4.5, and the desired result is then obtained by reading the number that appears under the cross-line on the B scale. For instance, it will be seen that 4.5 meters equals 177 inches. There are twenty-two of these constants graduated on the slide, which greatly facilitate the performance of many engineering problems. A list on the back of the rule gives the key letter and significance of each constant.

### Richardson's Merchant's Slide-rule

For the use of merchants and other business men, many of whom have not made a detailed study of mathematics and have not been instructed in the use of the slide-rule, Mr. Richardson has developed a simple rule illustrated in Fig. 2. At the top of this rule there are two scales marked $D^1$ and $D^2$, which are graduated similarly to the C and D scales of the ordinary slide-rule. These can be used for problems in multiplication and division. At the center of the slide there is a scale corresponding to the two upper scales on the rule, but reading in the opposite direction. This scale is marked CI, and is used to obtain reciprocals of the numbers graduated on the scale at the top of the slide. For instance, setting the runner at 2 on the scale marked $D^2$, the corresponding reciprocal 0.5 will be found on the scale marked CI.

One of the most valuable uses of this slide-rule is in the calculation of problems in percentage and interest, for which purpose it is the means of saving a great deal of time. At the bottom of the rule will be seen a scale marked $D^3$ at the left, while the word "Prin" appears at the right of this scale. At the bottom of the slide there is a scale at the left of which appears "%," while at the right of this scale is the word "Rate." Similarly, at the top of the slide there is a scale with "Days" marked at the right-hand end, while at the extreme top of the rule is a scale at the right-hand end of which appears the word "Int."

In order to explain the use of this rule for the rapid solution of problems of this kind, suppose it is desired to calculate the interest due on a loan of $4800 for seventeen days, interest being at the rate of 5¼ per cent. On the "Prin" scale, set the cross-line on the runner over 4800. Move the slide so that 5¼ on the "Rate" scale comes under the cross-line. Then without moving the slide, move the runner along until the cross-line is over 17 on the "Days" scale. The interest due will then be read under this cross-line on the top scale marked "Int." The amount due is found to be $11.91. This result can be obtained in a few seconds, where it would involve several minutes time for an average accountant to obtain the result.

* * *

## EXPOSITION AT SPRINGFIELD, MASS.

An industrial exposition and conference will be held in Springfield, Mass., May 26-June 2. This will be the first event of the kind ever held in the country, and is the result of the feeling in the great manufacturing centers of the eastern states and New England that something tangible should be done to fortify the industrial interests to meet conditions likely to follow the close of the European war. The exposition grounds are well situated; the buildings erected in the summer of 1916, are on a railroad siding and afford ample accommodations for expositions and conferences. Further information can be obtained from John C. Simpson, general manager, Springfield, Mass.

## NEW MACHINERY AND TOOLS NOTES

**Welded Stellite Tools:** Haynes Stellite Co., Kokomo, Ind. These tools consist of a drop-forged, heat-treated, carbon-steel shank to which a stellite cutting edge is electrically welded. They are made in all standard toolpost sizes and with straight, right-hand and left-hand shanks.

**Small Swaging Machine:** Etna Machine Co., Toledo, Ohio. While this machine will handle the usual run of small swaging work, it will swage any tapers that can be handled with a comparatively short die. Its greatest capacity is 1 inch in diameter and the dies are 3 inches long. The flywheel should run at 400 revolutions per minute.

**Universal Tool Grinding Machine:** Acme Grinder Co., Cincinnati, Ohio. This machine is intended for tool sharpening and small grinding of a similar nature. The headstock and the vise swivel in all directions. The vertical screw for elevating and lowering the knee is provided with a ball thrust bearing to reduce the friction.

**Universal Turret Table:** Milliken Machine Works, West Newton, Mass. This tool consists of a base, designed to be bolted to the machine table, and a revolving top. A tongue in the base fits in the slots of the machine table, while the revolving plate has T-slots and a hole for locating work centrally. This tool may be used on milling machines, shapers, surface grinders, drilling machines, etc.

**Shaping Machine for Locomotive Boxes:** Newton Machine Tool Works, Inc., Philadelphia, Pa. The principal features of this machine are a vertical feed and an angle-plate for mounting horizontally the part to be machined. The boxes are placed in a horizontal position so that the marks on the boxes are visible. The feed of this machine is accomplished by a pawl, and this arrangement insures a definite amount of feed at each stroke.

**Trumbull Tapping Machine for Thin Work:** F. S. Trumbull, Bridgeport, Conn. The essential part of this machine is a small electric motor, upon the shaft of which is mounted a Gronkvist automatic collapsible chuck. This machine will tap holes up to ¼ inch in diameter. Two coil springs force the work into the tap after it is placed in position and a pedal is used to back off the spindle. A switch automatically stops the machine when the pedal is released.

**Portable Band Wheel Grinding Machine:** W. C. Barnhart, Seattle, Wash. With this machine band wheels, pulleys, and similar work may be ground without being removed from their bearings. The grinding wheel is revolved simply by frictional contact with the surface being finished, so its use is limited to parts that can be driven at a peripheral speed of from 5000 to 9000 feet per minute. Varying the angle of the abrasive wheel with reference to the axis of the pulley changes the speed of the wheel.

**Hand Milling Machine:** Superior Machine & Engineering Co., Detroit, Mich. This machine is designed to handle fine work. Its range of mills is from ⅛ inch to 5 inches in diameter. If desired, a slotting attachment or vertical milling head may be applied in place of the regular head. Both the head and the knee slide are on the same column. In the back of the column is a two-speed gear-box, and in a box outside the column are two transposing gears; provision is made for obtaining a wide range of speeds.

**Plain Grinding Machine:** Fitchburg Grinding Machine Co., 76 Winter St., Fitchburg, Mass. In the June, 1914, number of MACHINERY, descriptions were published of the styles A and B, 6 by 15 plain cylindrical grinding machines which had just been placed on the market at that time by the Fitchburg Grinding Machine Co. As originally designed, the machines were equipped for belt drive, but in order to meet the demand for the use of electric power, machines of this type are now being constructed with an individual motor.

**Releasing Tap- and Die-holder:** Ideal Brass Co., Indianapolis, Ind. This tap, which is driven by two pins, is brought up to the work and continues to cut after the turret stops until its movement causes the pins to release. By adjusting the amount of tool travel after the turret stops, it is possible to work up close to a shoulder. When the holder starts to reverse, a roller runs up a taper groove until it grips the shank and backs up the tool. Left-handed threads may be cut by placing this roller in a second taper groove provided for the purpose. By placing rollers in both grooves, a non-releasing holder is obtained.

* * *

## PUTNAM CAR WHEEL GRINDER—CORRECTION

The net weight of the heavy-duty car wheel grinder built by the Putnam Machine Co. of Fitchburg, Mass. and described in the February number is 50,000 pounds with the motors, and 45,000 pounds without the motors. Owing to a typographical error the weight was stated in the description to be 5000 pounds.

## THE AMERICAN INSTITUTE OF WEIGHTS AND MEASURES

The revival of the agitation for the adoption of the metric system has aroused the opponents of the system, and an organization called the American Institute of Weights and Measures was formed in 1916 to support the present English system of weights and measures. At a meeting of the council of the institute, held at the Engineers' Club, New York City, February 19, the following officers were elected: president, W. R. Ingalls; vice-presidents, Henry D. Sharpe and D. H. Kelly; treasurer, Walter M. McFarland; commissioner and secretary, F. A. Halsey.

The objects of the new institute are declared to be: the maintenance and improvement of our present (English) system of weights and measures, for the good of our commerce and industry and the well-being of our country; the education of the people with respect to the importance of our weights and measures, through the dissemination of correct information with respect to them and to the danger inherent in changes of our basic standards of measurement; the improvement of old and the development of additional standards as they may be needed by reason of new conditions in commerce, industry, science and engineering; the promotion of wise legislation for the conservation of our basic English units of weights and measures, and opposition to hasty legislation, involving changes from our fundamental English standards.

The annual dues of association members are $100 for associations which are national in scope and $25 for all others. The annual dues of corporation members employing less than 500 employes are $25, and of those employing more than 500 and less than 1000, $50; and $25 for each additional thousand employes, or fraction thereof, up to a maximum of $500. The annual dues of individual members are $5.

The institute will open offices in New York City. Applications for membership should be sent to F. A. Halsey, commissioner, Hill Bldg., Tenth Ave. and 36th St., New York City.

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## SHEET METAL TESTING MACHINE

*Tensile strength tests are unsatisfactory for determining the quality of thin sheet metal that is to be worked in power presses, etc., because of two reasons: in the first place, such tests do not yield reliable data for very thin sheets; second, the quality of metal which is to be worked by drawing, stamping, folding, etc., is dependent upon ductility and similar properties rather than upon tensile strength. The following article describes a machine for determining what is known as the Erichsen value, i. e., the depth in millimeters before the metal is torn, of an impression made by forcing the sheet metal through a die. A chart gives Erichsen values for various metals, based upon data obtained by several thousand tests.*

In determining the quality of metal sheets, the only method used in the past has been the "tensile strength" test. The tensile strength testing machine does not give reliable results

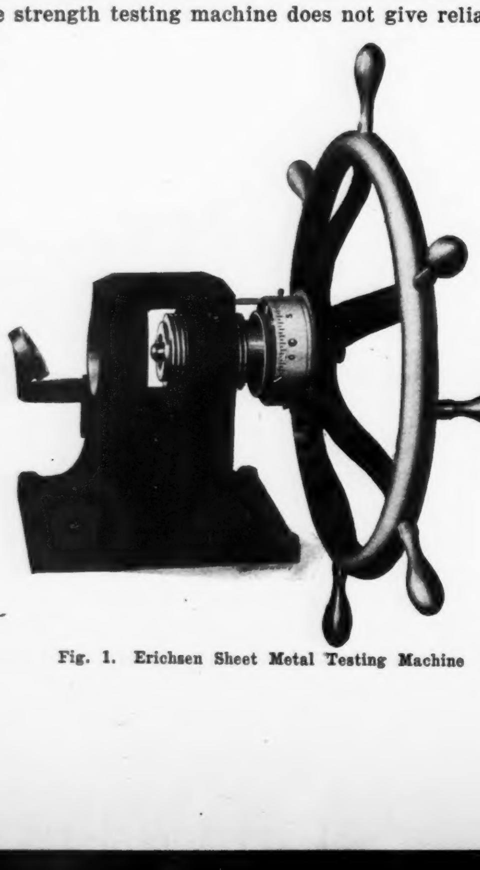


Fig. 1. Erichsen Sheet Metal Testing Machine

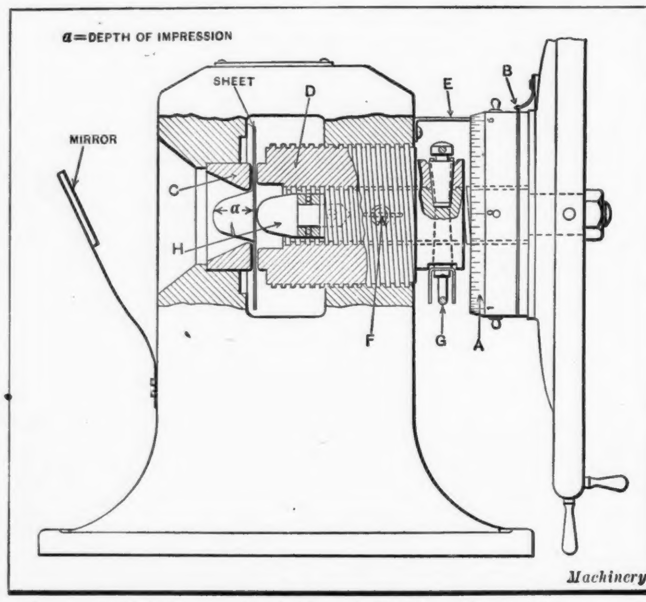



Fig. 2. Partial Cross-sectional View of Machine, showing Arrangement of Die, Tool and Holder in which Specimen is secured

with thin sheets, and in the practical application of metal sheets it is not so much the tensile strength, but the drawing, stamping, compressive and folding qualities which determine whether the material is well suited for manufacturing purposes. A. M. Erichsen, a Norwegian metallurgical engineer, has devised a method for testing metal sheets on which patents have been granted in the U. S. A. and in all foreign

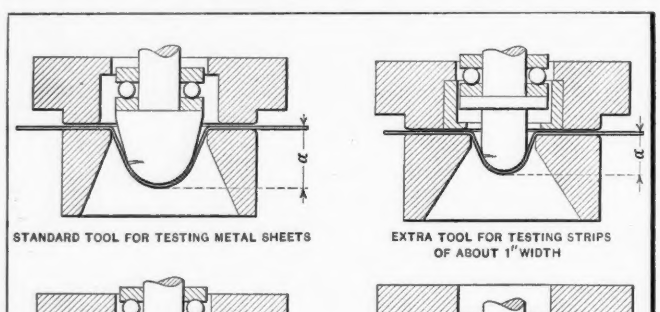



Fig. 3. Dies, Tools and Work-holders for testing Various Materials

countries. Herman A. Holz, 50 Church St., New York City, has the American sales agency for this machine. This method determines in a simple and rapid manner the actual workability of metal sheets to the point of fracture. A specimen of the sheet or strip is clamped between two dies and held in such a way that the metal has "play" and can flow, while a tool having a rounded end (a perfect semi-ball) is moved gradually forward under the influence of a ram, actuated by a micrometer screw, until fracture occurs. The test piece is under the permanent observation of the operator, so that the point of fracture can be determined with great accuracy (to 0.01 millimeter). The depth of the impression required to produce fracture can be read off directly from a micrometer scale and represents the "Erichsen value" of the sheet, which is a basis of the workability of all metal sheets for manufac-

turing purposes. Great tenacity combined with high tensile strength will give the best drawing and compressive values, which, however, are neither proportional to the effective modulus of elongation nor to the ultimate tensile strength.

### Advantages of the Erichsen Method

The advantage of the Erichsen method lies, first of all, in the possibility of obtaining actual test figures in a few moments, and without any previous preparation of the test piece. It is therefore possible to test in a short time a large number of different qualities of metal sheets or strips, thus providing an effective means of control both for the manufacturer and the purchaser of the material. Another advantage is that all Erichsen machines are made from the same precision gages and are adjusted in exactly the same manner; hence the results obtained in testing homogeneous material are strictly comparable. It is therefore easy to lay down standard specifications regarding the quality of metal sheets by simply agreeing on certain minimum Erichsen values. Another important point of advantage is that the "dome" produced by the indentation permits ready observation of the macro-structure of the drawn metal, often giving valuable information about the treatment which the material has undergone. The operation of the machine is so simple that any intelligent workman can readily use it. While its high accuracy makes it suitable for use in testing laboratories, the machine can just as well be used in the shops, as it is of very solid and rugged construction.

### Observation of Tested Specimen

While the Erichsen machine permits the accurate measurement of the thickness of the test specimen, which should be noted when starting the test (see instructions for operating the machine), there are two other points that should be observed: (1) Formation of the fracture. Investigate whether the fracture runs around the dome or whether a previous fracture in a certain direction is noticeable. In the latter case the metal is fibrous and not very well suited for drawing and folding purposes; it will then also have a low drawing value. Pronounced fibrous formation is often noticeable in first quality sheet iron and tinned iron sheets, while in the case of iron and steel strip the fibrous formation disappears more and more when being repeatedly annealed and cold-rolled. On the other hand, non-ferrous sheets are usually not fibrous, with the exception of zinc sheet, the workability of which is thereby considerably reduced. The second point to be observed is: (2) Macro-structure. Investigate whether the dome retains a surface similar to that of the sheet in its original state or whether it becomes rough or close-grained. If it becomes rough, it is not suitable for drawing or pressing operations. This loose structure appears in ferrous and non-ferrous sheets, and is caused by excessive annealing. The Erichsen method thus provides also a means of controlling the proper annealing process. The dome frequently appears close-grained on the surface, mostly in copper and brass sheets. In copper sheets this results from the influence of reducing gases on copper protoxide, which occurs chiefly when copper is annealed in open reverberatory furnaces. This fine grain can often be seen in copper sheets with the naked eye. In brass sheets, this evil may be traced to various causes; very often it is produced by too sharp pickling. A high-quality drawing and pressing sheet should, therefore, have: (1) A good Erichsen value. (2) As little as possible fibrous formation. (3) A smooth surface of the testing dome, which must not show a rough or close-grained appearance. Furthermore, the sheet must be free from scale and flaws (noticeable with the naked eye), and any blisters and hollow spots that may be present in the sheet will show up immediately upon commencing the test.

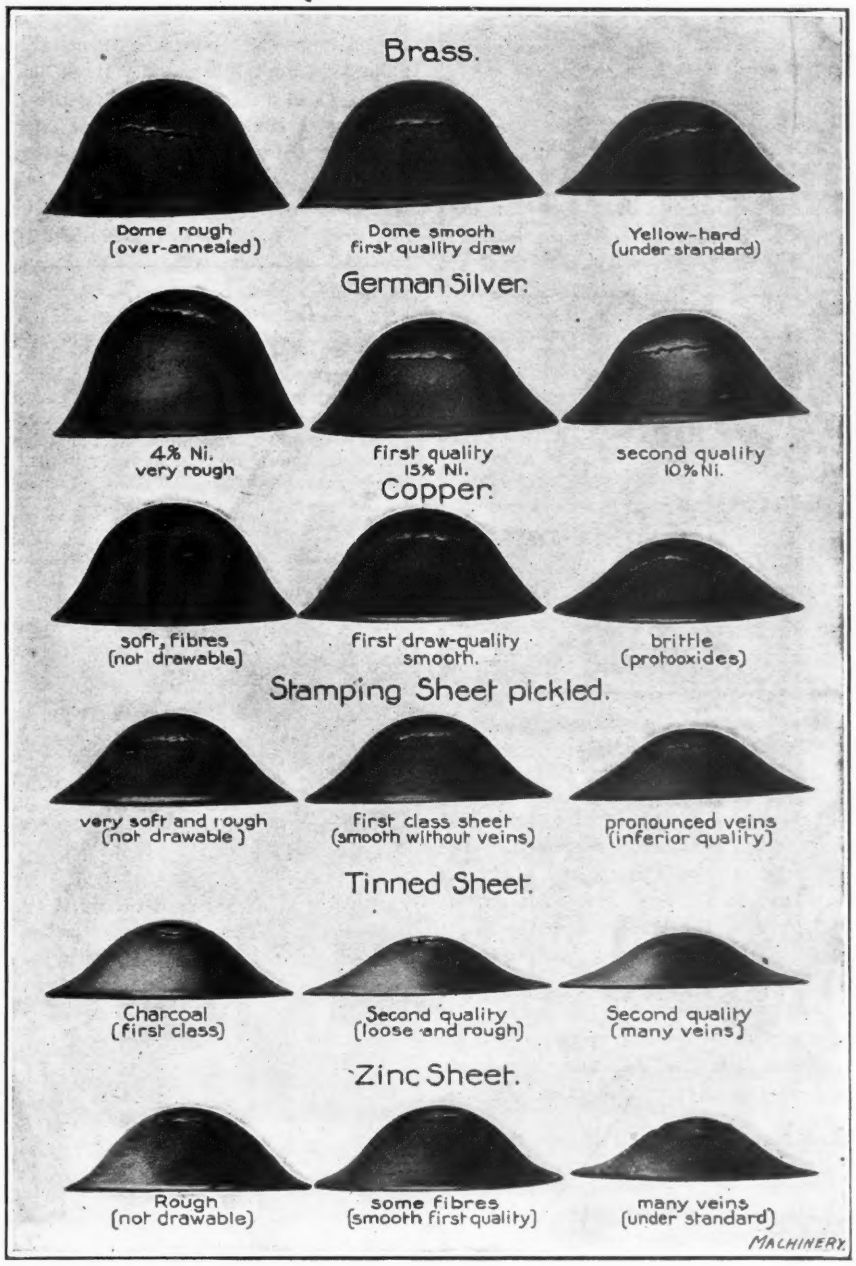



Fig. 4. Fractured Test Specimens of Different Materials showing Variations in Erichsen Value and Nature of Tear

### Standard Specifications for Trade Qualities

The curves in Fig. 5 show the relation between the thickness and the Erichsen value of good metal sheets. Their meaning to the trade will be readily understood; a brass stamping sheet of, say, one millimeter thickness, should not crack in the Erichsen machine below 14.25 millimeters depth of indentation. If it has less than 14.25 millimeters Erichsen value, its quality is below standard. These standards were laid down by Mr. Erichsen by averaging several thousands of tests in his many years' experience. They permit excellent comparisons to be made between the manufacturer and purchaser of the sheets, although most of the large users of metal sheets will work out special standards for their various requirements. In case the drawing values determined exceed those given in Mr. Erichsen's standard curves, the sheet may be said to be of good trade quality or even better.

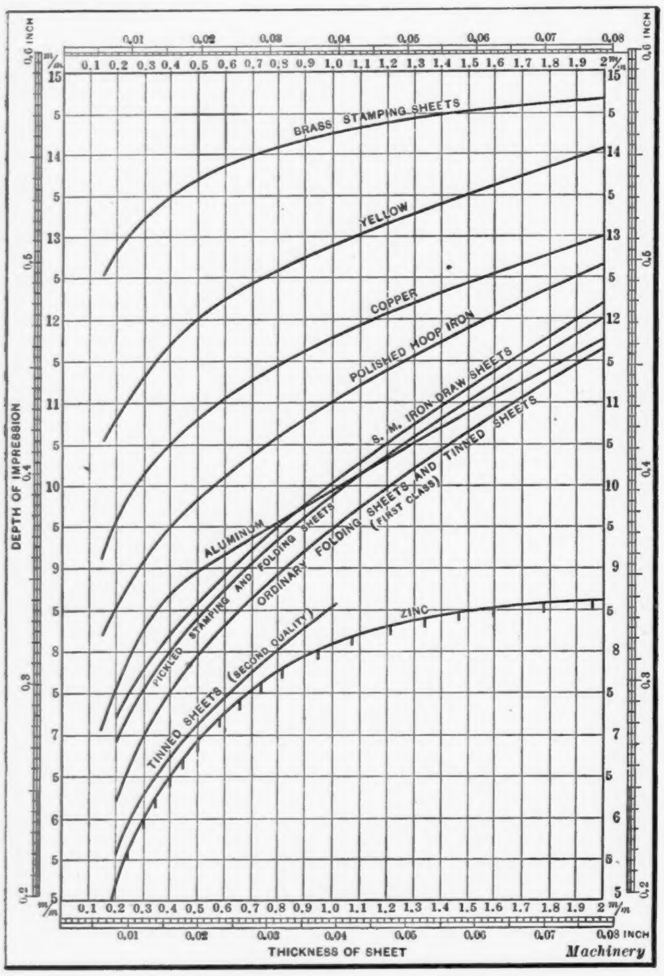



Fig. 5. Chart showing Normal Erichsen Values for Various Thicknesses of Different Kinds of Sheet Metal

### Directions for Use of Machine

The first operation is to measure the thickness of the sheet to be tested. Set scale *A*, Fig. 2, to zero by shifting the movable collar on which it is engraved until the spring *B* snaps into a small hole. Insert the sheet specimen (about 3½ by 3½ inches) in die *C*, turn the wheel until the sheet is firmly clamped between die *C* and holder *D*, as shown in the diagram, and read off the thickness of the sheet on scale *A*, which is divided into 0.01 millimeter. The total range of this scale is 5 millimeters, and readings can be continued on scale *E*. After the thickness of the sheet has been measured, turn the handwheel back five small divisions on scale *A*

TABLE I. NORMAL ERICHSEN VALUES OF 1/64-INCH ANNEALED FERROUS SHEETS

| Material | Depth, m. m. | Depth, inch. |
|---|---|---|
| S. M. hoop iron, polished | 9.5 | 0.374 |
| S. M. sheet, first class | 8.2 | 0.323 |
| S. M. stamping sheet, pickled | 8.0 | 0.315 |
| Common folding sheet | 7.5 | 0.295 |
| Charcoal tinned sheet | 7.5 | 0.295 |
| Second quality tinned sheet | 6.7 | 0.264 |
| Brass or copper plated sheets | 8.5 | 0.335 |

*Machinery*

(0.05 millimeter), in order to give the test piece a certain amount of play, which is the same for all gages of sheet (*i. e.*, 0.05 millimeter). To secure the holder *D* in this position, tighten wing screw *F* at the right side of the machine. Now shift scale collar *A* until the zero point of the micrometer scale meets the zero point on scale *E*. Then shift the gear by pressing against milled ring *G* and turn the handwheel to the right (in clockwise direction). Tool *H* now moves forward into the sheet, and the bulging will be immediately noticed in the mirror.

Watch the image carefully in the mirror until the moment of fracture is reached, when the depth of impression is read off on scale *E* (in millimeters) and on *A* (in hundredths of a millimeter). In approaching the point of fracture, the wheel should be turned slowly, so that readings may be accurate to 0.01 millimeter. After the depth of impression has been read and noted, loosen the screw *F*, turn the wheel quickly to the left, until the gear shifter snaps automatically back to the outer gear, and the machine is ready for another test. It is obvious that the machine should be mounted firmly and in such a position that as much light as possible falls on the dome of the indentation, so that it can be closely watched in the mirror. Not only the threads, but also the die and tool should be kept lubricated. It will be noticed in testing thick sheets (2 to 5 millimeters) that the power required to produce fracture is considerably reduced, if grease is kept on the die and tool; this question of lubrication, however, does not influ-

TABLE II. NORMAL ERICHSEN VALUES OF 1/64-INCH ANNEALED NON-FERROUS SHEETS

| Material | Depth, m. m. | Depth, inch |
|---|---|---|
| Brass stamping sheet | 13.5 | 0.532 |
| Yellow metal | 11.7 | 0.461 |
| Pure nickel | 11.5 | 0.453 |
| German silver stamping sheet | 11.5 | 0.453 |
| A-1 German silver sheet | 11.0 | 0.433 |
| Copper sheet | 10.5 | 0.413 |
| Aluminum sheet | 8.7 | 0.343 |
| Zinc sheet | 6.5 | 0.256 |
| Silver sheet, 0.875 | 7.5 | 0.295 |

*Machinery*

ence in any way the measurement of the Erichsen value. The size of the test pieces for use in the standard machine should be 3½ by 3½ inches, and strips up to 2⅜ inches in width can be tested with the standard tools. For narrower strips up to 1 inch and 5/16 inch, respectively, additional interchangeable tools are required.

### Tube Testing

Pieces of metal tube are cut open and carefully straightened out with a mallet. The Erichsen test is then conducted in the same manner as with sheet metal. The appearance of the surface of the dome will then often give valuable information. Drawing grooves (caused by tools in the tubemaking machinery) and long drawn flaws will be shown as sharp transverse fibers and result in premature fracture, while excessive annealing will be recognized in the known manner (see under "Observation of the Tested Specimen").

### Testing Spring Quality of Sheets and Strips

Sheets and strips are often purchased on the specification of "spring hardness." These grades are to be based upon the deflection, and the values given in Table III refer to brass sheet of 0.5 millimeter (0.02 inch) thickness.

### Hardness Tests

As the depth of the Erichsen impression varies, on material of identical composition, in a certain relation to the Brinell hardness of the sheets, the Erichsen machine may also be looked upon as a valuable apparatus for determining the degree of hardness of iron and steel sheets and strips. The Erichsen machine thus offers means for the manufacturing plants to establish their own standards also for the hardness of metal sheets and strips, which cannot be determined accurately by the well-known methods of hardness determination.

TABLE III. SPRING HARDNESS AND ERICHSEN VALUES FOR BRASS SHEETS [1]

| Grade of Spring Hardness | Soft | ⅛ Hard | ¼ Hard | ½ Hard | ¾ Hard | ¹/₁ Hard | Spring Hard | Double Spring Hard |
|---|---|---|---|---|---|---|---|---|
| Deflection, per cent | 0 | 3 | 5 | 10 | 15 | 25 | 35 | 50 |
| Erichsen value | 13.7 | 12.3 | 11.3 | 10.5 | 9.8 | 8.5 | 7.4 | 7.2 |

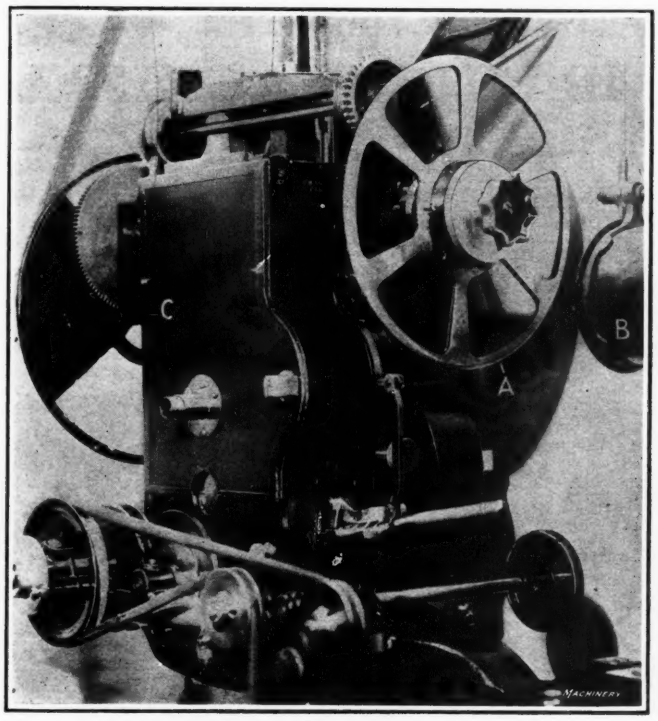
*Machinery*

[1] The depth of the Erichsen impression of sheets of other thickness is proportionate to the standard Erichsen curve.

## COLORED MOVING PICTURES

While colored moving pictures are not new, recent improvements have been made in the color process which may result not only in increasing the popularity of the movie show (if that be possible) but in making moving pictures much more effective in commercial work, either as a means of advertising or selling goods. The Prizma pictures, which represent the latest development in the color process, are not only superior to the plain black-and-white pictures because of the natural color effects obtained, but have a "depth" which is more realistic.

The Prizma films are, to the casual observer, similar to films for black-and-white pictures, although they possess latent values obtained by the use of a gelatin color screen or filter on the camera. This screen, which is between the film and the lens, is in the form of a thin circular disk and has four equally spaced sections with two pairs of complementary colors. The first pair is composed of red and green-blue, and the second of yellow and blue. When the camera is in use, one exposure is made for each of the four colors, so that four negatives are obtained for each revolution of the color screen. These exposures occur at the rate of twenty-four a second and the screen is geared to revolve six revolutions per second, in unison with the movement of the film, so that




**Projector equipped with Color Wheel Attachment**

it makes one complete turn during the time that four exposures are made.

The camera controls a single strip of film of standard width, which is perforated on the edges as usual and is pulled down, step by step, back of a single lens. When an exposure is made through the red screen or color filter, the light rays, excepting from any shades of red that may be before the camera, are excluded; similarly, all but the green rays are excluded by the green filter, and so on. Between the film and the lens there is a shutter to cover the film at the time it is being drawn down after each successive exposure. Simultaneously with every fourth exposure and at the time that the red screen is opposite the lens, a little light is admitted to the edge of the film through a special aperture, thus marking every fourth or red-screen negative so that it can be distinguished readily from the others. This mark enables the different film sections to be joined together properly, or so that the film, from one end to the other, has four successive exposures for each revolution of the color screen. When the film has been joined in this way, it will keep in step with the color wheel attachment of the projector after it has once been synchronized.

The positives used in reproducing the picture are printed as usual and may be exhibited on any standard projector after equipping it with a color wheel attachment, as shown in the accompanying illustration. The color wheel *A* is driven through gearing of such ratio that it makes one revolution for a film movement equivalent to four pictures or exposures, the same as the color filter of the camera. This projector color wheel is held in a given position by a spring detent, which engages any one of six slots (the number of slots corresponding to the number of color screens), so that the wheel can be synchronized with the film when starting a reel, by simply turning it one or more screen sections backward or forward, as may be required. The light from *B* passes through the different screens and then through the film, the movement of which is controlled by the mechanism in projector *C*.

While the spectator has the impression that each picture contains all of the colors and tints that appear to the eye, this is an illusion; what actually is shown is a red picture, a blue-green picture, an orange-yellow picture and a blue picture. These four shades photographically cover the entire range of visible colors and follow each other in such rapid succession that, owing to the persistence of vision, the impression remains that all of the colors and tints appear simultaneously. For instance, the red, white and blue of the American flag apparently appear simultaneously, although, in reality, these colors follow each other in rapid succession, but the impression remains that all three colors were seen in every picture. Black-and-white pictures may be shown by simply swinging the color wheel *A* away, so that the light does not pass through it, the geared drive being so arranged that one gear revolves about the other, planetary fashion, when changing the position of the wheel.

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## CORROSION OF METALS

BY W. H. DOOLEY [1]

When we consider the rapidity with which iron, steel and other metals corrode under ordinary conditions, with the resultant expenditure of many millions of dollars annually for depreciation and expense of renewals, we see that the problem of metal corrosion is one of great importance to the metal trades. This question also interests a large proportion of civilized people, because the security of life depends, to a large degree, on the durability and safety of structures and machines.

What is corrosion? Everyone has noticed the reddish-brown deposit that gathers on the surface of iron and steel that has been exposed to the air—particularly damp air. This reddish substance is called "rust" by the ordinary person, and is composed principally of oxide of iron, which is formed of two parts of iron and three parts of oxygen. It is represented in most technical magazines and books by the symbol $Fe_2O_3$. The first two letters represent the Latin term ferrus, meaning iron, and the letter O represents oxygen. The iron and the oxygen from the air unite in such a way that they cannot be separated without resorting to a process equivalent to smelting. Oxide of iron has great attraction for water, so it absorbs moisture from the air. The corrosion of iron or steel is the iron oxide combining with water. The result is similar in composition to iron ore, which is smelted and reduced to iron in a blast furnace. Corrosion of metal is often spoken of by workmen as the "eating of metals"; by scientific men it is called "oxidation."

Corrosion takes place first on the surface of iron and steel and follows the path of least resistance. It does not take place evenly over the surface of the metal. Sometimes it will penetrate a plate before attacking the adjacent surfaces. This is due to the fact that corrosion varies as the material in the metal and the treatment the metal receives in the iron mill. For example, the more porous the metal the more rapidly it will corrode. Blow-holes furnish a splendid foundation for corrosion, as do also such impurities as slag, scale or segregated parts of the metal. This is the reason why it is impossible to tell just why one piece of metal will corrode more quickly than another piece of the same kind.

Corrosion takes place faster in the presence of acids than under ordinary conditions. This is why corrosion proceeds

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more rapidly after a thunder shower, when the lightning has changed part of the nitrogen of the air into nitric acid. Alkalies seem to retard corrosion. Certain impurities, such as carbon, silicon and phosphorus, have a tendency to resist corrosion, which is why cast iron does not rust rapidly in air, while other impurities, like manganese and sulphur, tend to increase corrosion. Steel corrodes according to the amount and condition of carbon in it. It is known that steel may contain carbon in either a free or a combined condition. That is, the carbon may be present in steel in the form of graphite, when it is called free carbon; or it may be united with the iron in such a way that it cannot be separated, when it is called combined carbon. The free carbon prevents corrosion. When corrosion once sets in, it increases progressively. It is 50 per cent more rapid during the second than during the first year. This is due to the fact that in the process an acid is formed which tends to increase the rate of corrosion. For this reason corrosion should not be allowed to continue, or even begin.

Up to the present time, no process has been discovered that will completely prevent corrosion. There are various materials, like paints and oils, that may be applied to the surface of the metal and reduce corrosion to a minimum. But before any substance can be applied, the rust must be removed. Any vigorous treatment may be employed to remove the rust, and the process will not crack, injure and break the metal. Rust is usually removed on a large and economical scale by scraping and hammering. The scraping is done, on a flat surface, by vigorously rubbing a steel-wire brush, both lengthwise and crosswise, thus removing the loose scales and projecting masses of rust. A hammer, file, cold chisel and a painter's wall scraper should then be used. The wall scraper should be used to remove any thick formation of rust. After this treatment, the steel brush should again be used, and should be followed by coarse emery cloth or sandpaper. Sometimes steel wool or steel shavings are used for the final removal of all loose and scaly formation. The process of rust removal is completed by removing the finely powdered dust and wiping the surface clean with a dry cloth. Sometimes the removal of rust is made easier by the use of a painter's torch, as this evaporates the moisture in the iron rust and reduces the scaly corrosion to a powder. Of course, the best results are obtained with a sandblast, but this is often too expensive to use in the ordinary machine shop.

When thoroughly cleaned, the metal may be covered with the material that will prevent corrosion to a great degree. In order to be effective, the paint or oil that is to be used should not damage the metal and at the same time should not allow the oxygen and moisture of the air to come into contact with it. In fact, any material to be used for preventing rust on iron and steel should be easy to apply; must protect the metal, to a great extent, from the air; and must cost but little. Oils and greases are used to protect iron and steel surfaces only when the exposure is not permanent or severe. Machinery and tools are often "slushed" with grease during a period when the shop is closed. Various paints, varnishes and oils are used. They are very good as long as they prevent water from coming into contact with the metallic parts. Very often, though, the oil dries out of the pigment, leaving the dry paint porous enough to absorb moisture from the air. This is particularly true with regard to oxide paint pigment that is mixed with oil and used as a coating for structural steel and iron.

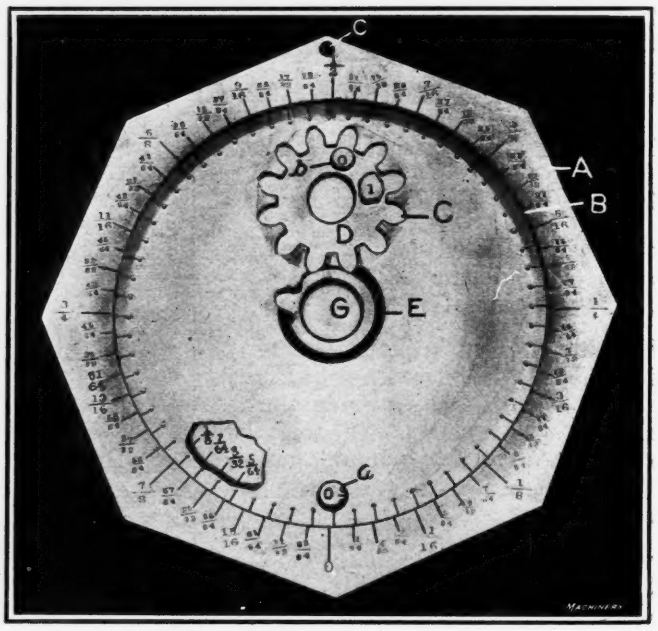
Progressive manufacturers and shop men are beginning to realize that it is absolutely necessary to have a definite arrangement whereby corrosion is removed from metallic surfaces at definite periods. A large number of men are constantly employed on large structures removing the rust and recovering with a suitable paint. If all owners would take due precaution, frightful accidents, causing the loss of life, such as the collapse of large steel structures, bridges, gas works and products of large railways, would be reduced to a minimum.

* * *

Extensive molybdenum deposits have been discovered near Mandal, Norway. The present production is about three tons per week.

## PROGRESSIVE FRACTION ADDER

Fraction adders similar to that here described have for a long time been generally known, but this one contains some new features of interest. It consists of six parts, *viz:* base *A*, rotating disk *B*, pinion *C*, center stud *D*, one-tooth pinion *E*, and main stud *G*. *A* is divided into sixty-four graduations which line up accurately with the same number of graduations on disk *B*. Opposite each graduation on base *A* is a fraction. The graduations are marked 0, 1/64, 1/32, 3/64, 1/16, etc., up to 63/64 in a counter-clockwise direction. There is another set of figures on *A* underneath disk *B*, which can be seen through the hole *a*. These fractions also start with 0 and end with 63/64, but in this case they progress in a clockwise direction. The shoulder stud *D* extends only through *B*, thus giving it freedom to rotate. Shoulder stud *G* extends through *B* and is riveted to base *A*, allowing free rotation of part *B*. Pinion *E* is securely fixed to stud *G* which, being fixed to base *A*, holds it in a predetermined position. Through hole *b* will be seen the character 0 under pinion *C*. The figures 0, 1, 2, 3, 4 and 5 are stamped on disk *B* equal distances apart,




Device for adding Fractions up to Six Inches

and become visible through the hole *b*, as *C* rotates one-sixth revolution for every complete revolution of *B*.

The operation of the device is simple and may best be understood by an example. The adder as illustrated is approximately in the neutral position. Suppose the fractions ¼, ⅜ and ½ are to be added. The point of a lead pencil is placed in the small hole on *B* corresponding with ¼ on *A*, and with the pencil as a lever, *B* is moved in a clockwise direction until the graduation at the point corresponds with 0 on base *A*. Then the pencil point is placed in the hole corresponding to ⅜ and *B* is rotated until the point lines up again with 0 on *A*. This operation is again repeated, placing the pencil point at the graduation corresponding to ½. Now the sum of these three fractions may be read directly. Through hole *b* the figure 1 is visible and through hole *a* ⅛ is visible, indicating that the sum is 1⅛. When the addition of fractions exceeds 1 it means that *B* is rotated somewhat more than one complete revolution, and in this case *C* engages with the tooth on pinion *E* and rotates one-sixth revolution, exposing the numbers 1, 2, 3, etc.

The hole *c* is for hanging up the adder. The principle involved in the rotation of *C* is the well-known Geneva movement. Except for the two studs this adder is made entirely of aluminum. The illustration and description were secured through the courtesy of F. J. Perry, Nashua, N. H. V. B.

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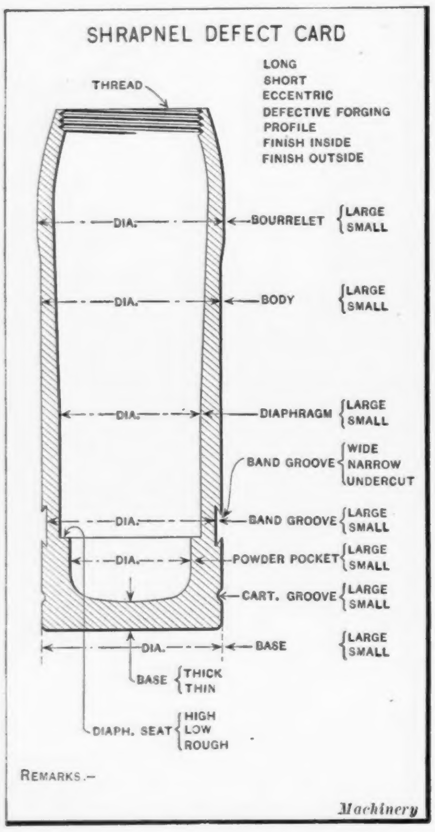
The *Engineer* of London states that the British shipyards now have double the output that three years ago was considered maximum.

## SHRAPNEL DEFECT CARD

Any mechanical man will concede the value of a sketch for conveying a mechanical idea in preference to verbal explanation. It is difficult for mechanical men to express themselves without the use of a pencil, and sketching is really a great assistance in conveying thought. The Vermont Farm Machine Co., Bellows Falls, Vt., has taken advantage of this fact in connection with shrapnel inspection. The shrapnel defect card shown herewith has proved an effective way of conveying information from one inspector to another.




Reproduction of Shrapnel Defect Card

On these cards, which are printed in quantity, the inspector finding the body diameter large puts a check mark after the word "Large" and rolls the card up, slipping it into the shell. That shell is then sent along with the others to what corresponds to a repair department, where there are experts who pass on the advisability of scrapping or repairing the shell. The advantage of this defect card is the ease with which the repair men can determine which portion of the shell is defective. The expense of printing a card of this nature is not greatly in excess of any printed form card. For this reason the idea here incorporated should be applicable to the inspection of any kind of duplicate machine parts. V. B.

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## LARGEST GYRATORY CRUSHER

The largest gyratory crusher in the world has been installed at the plant of the Michigan Limestone & Chemical Co. at Calcite, Mich., by the Kennedy-Van Saun Mfg. & Engineering Corporation, New York City. It is 34 feet high, weighs 700,000 pounds, and has a capacity of 25,000 tons of limestone each twenty hours. The crushing space between the head and concaves holds 30 tons of stone; while the hopper, which flares out above the head and concaves with an outside diameter of about 22 feet, holds 35 tons more. The spider is made in a single casting and is within one inch of the railroad height limit even when shipped in a well-bottom car. On account of its weight, the top shell could not be shipped in one piece and was therefore constructed in two horizontal sections. These are connected by heavily flanged male and female tapered machine joints, securely bolted, so that the strength of the shell is increased instead of reduced. The crusher is driven by a 300-horsepower motor. As continuity of operation is of greatest importance, the English rope system is used. The 1¼-inch manila ropes lead over a 66-inch cast steel sheave having eighteen machined rope grooves.

The main shaft, which is made of hydraulically forged steel, is about 3 feet in diameter at its largest part and about 28 feet long. It is designed on the basis of a maximum fiber stress of 10,000 pounds per square inch. The eccentric is of the spherical ball-and-socket type and is self-aligning. Its steel bearing has a phosphor-bronze bushing that is constructed in two parts. The pressure between the shaft and the bearing is designed not to exceed 175 pounds per square inch. Eccentric and thrust collars carry the weight of the eccentric and are lubricated by a positive oil pump circulating system. As there is an oil strainer in circuit, a continuous supply of clean oil is secured. The spider is set clear of the concaves, so that the latter can be reset without disturbing the head or the spider. The concaves are made sectional and in four horizontal belts to facilitate handling the sections and so that only the worn parts need be renewed. The head is rigidly secured to the shaft on its smooth tapered part and thus reinforces the shaft at the place where the greatest stress is applied. It is held in position by a nut sleeve fixed to the shaft, but without threads on the shaft. This nut operates in a follower "zinced" in the top of the head. As a result, the tendency of the head to rotate on the shaft forces the head down tightly on the tapered part of the shaft, so that it is automatically locked in position. The head and concaves that take the principal wear from crushing are constructed of semi-steel castings of a special mixture and are deeply chilled on their working surfaces so as to have wear-resisting qualities. They have a maximum fiber stress of 3500 pounds per square inch.

## PERSONALS

C. C. Cleland has been appointed sales manager of the Reliance Gauge Column Co., Cleveland, Ohio, succeeding F. Roberts.

H. F. Wright, formerly with the Weston-Mott Co., Flint, Mich., has been made factory superintendent of the Hannifin Mfg. Co., Chicago, Ill.

J. A. Nelson has resigned the position of vice-president of the East Jersey Pipe Corporation, New York City. Mr. Nelson is taking a short vacation and has made no plans for the future.

Joseph R. Greenwood has resigned his position of general manager with the Ballwood Co., and has associated himself with Charles H. Higgins, architect and engineer, 30 Church St., New York City.

E. Carlson, for the past two and one-half years assistant superintendent with the Stewart Die Casting Co., has resigned to take the position of chief engineer with the Indiana Die Casting Co., Indianapolis, Ind.

Spencer Weart, second vice-president of the Bound Brook Oil-less Bearing Co., Bound Brook, N. J., was recently elected president by the board of directors, and George O. Smalley, general manager, was elected treasurer.

G. W. Wagstaff, who has heretofore represented the Bethlehem Steel Co. in the northern Ohio territory, has associated himself with the Onondaga Steel Co., Inc., Syracuse, N. Y., and will represent this company in northern Ohio, northern Pennsylvania, Buffalo and Detroit.

H. L. Harrison has joined the Modern Tool Co., Erie, Pa., in the capacity of factory manager. Mr. Harrison was formerly connected with the Packard Motor Car Co., the Maxwell-Briscoe Co. and the American Car & Foundry Co. He has been for many years engaged in factory supervision and tool design.

George M. Meyncke, engineer with the Dayton Engineering Laboratories Co., Dayton, Ohio, has resigned, and joined the Hyatt Roller Bearing Co., Newark, N. J., as engineer in charge of machine tool design, with headquarters in Cincinnati, Ohio. Mr. Meyncke will devote his energies to promoting the use of Hyatt roller bearings in machine tools.

William H. Bennett, who for nearly a year has been advertising manager of the Searchlight Co., Chicago, Ill., has joined the force of the Service Motor Supply Co. of Chicago. The change was made because of the consolidation of the Searchlight Co. with the Air Reduction Co. of New York City, and the removal of the Searchlight interests to the East.

C. A. Call has been appointed assistant sales manager and advertising manager of the Gurney Ball Bearing Co., Jamestown, N. Y., succeeding Otto Bruenauer. Mr. Call was formerly manager of publicity of the Terry Steam Turbine Co., Hartford, Conn. and prior to that engagement was for five years connected with the advertising department of the General Electric Co., Schenectady, N. Y.

A. H. Ackermann, formerly vice-president and general manager of the U. S. Light & Heat Corporation, and C. C. Bradford, formerly sales manager of the same concern, announce the formation of the Bradford-Ackermann Corporation, with offices in the Forty-second St. Bldg., New York City, to represent manufacturers of electric apparatus, factory, automobile and railway supplies for domestic and export trade.

Frank M. Erb, formerly superintendent of production of the R. D. Nuttall Co., Pittsburg, Pa., has resigned, and will open an office in the Second National Bank Bldg., Pittsburg, early in March as a manufacturer's district representative. Mr. Erb will handle castings and forgings, and among the companies he will represent are the National Forge & Tool Co., Erie, Pa.; the Silver Mfg. Co., Salem, Ohio; and the Standard Steel Casting Co., Cleveland, Ohio.

W. S. Rogers has resigned as president of the Bantam Anti-Friction Co., Bantam, Conn., but will continue to fill the position of chairman of the board of directors, and will act in an advisory capacity. Miss Nellie Scott, who has been with the company since its beginning, was elected president and general manager; and Miss Ruth Edwards, who has been with the company for nearly eight years, was elected treasurer. Henry Edwards was elected vice-president and C. B. Heath, secretary.

E. B. Merriam, for several years assistant engineer of the switchboard department of the General Electric Co., Schenectady, N. Y., has resigned to head the industrial service department of the company, recently organized to supervise the education, employment and provision of opportunities for advancement of the employes at the Schenectady plant. Mr. Merriam has been connected with the General Electric Co. for sixteen years, starting as a student in the testing department, and later doing service in commercial, manufacturing and engineering development and research work.

Dr. W. F. M. Goss, for many years associated with the schools of engineering, Purdue University, Lafayette, Ind., and since 1907 dean of the college of engineering of the University of Illinois, Urbana, Ill., has resigned, to take the presidency of the Railway Car Manufacturers' Association. The Railway Car Manufacturers' Association, of recent origin, is made up of representatives of fifteen different concerns engaged in the manufacture of railway freight and passenger cars. It will seek to establish cooperative relations with the purchasers of cars and to aid especially in the matter of standardizing the design and specifications.

C. K. Lassiter has been appointed vice-president of the American Locomotive Co., 30 Church St., New York City, in charge of manufacturing. Mr. Lassiter entered the service of the Richmond Locomotive Works in 1892 as clerk in the piecework department. In 1894 he was made chief clerk to the late Joseph Bryan, then president of the Richmond Locomotive Works, and in 1902 was transferred to the Schenectady plant of the American Locomotive Works as chief clerk to the general manager. He was later appointed mechanical expert in charge of designing, developing and maintaining all shop equipment, shop systems and piecework departments. He developed and installed the new drop-hammer department for making forgings for all the company's plants and also standardized the small works department. In 1907 he was transferred to the New York office and made mechanical superintendent in charge of all betterments, designing, specifying and maintaining shop equipment and power-house operations for all the plants. Mr. Lassiter is also president of the Baush Machine Tool Co., Springfield, Mass., and president of the Quigley Furnace & Foundry Co. of Springfield.

## OBITUARIES

F. E. Reed, formerly president of the F. E. Reed Co., Worcester, Mass., now part of the Reed-Prentice Co., died at his home in Thompson, Conn., February 18, aged sixty-nine years. Mr. Reed retired from active business in 1912.

Charles T. Schoen, who is given credit as being the originator of the pressed steel railroad car, died at his home in Moylan, near Philadelphia, Pa., February 4, of pneumonia, aged seventy-two years. Mr. Schoen began the manufacture of pressed steel specialties for wooden cars and established a small plant in Allegheny, Pa., now known as the North Side, Pittsburg. A few years later he organized the Pressed Steel Car Co., and was its president when he retired from that business fifteen years ago. He then built a plant at Butler, Pa., for the manufacture of the Schoen pressed steel car wheels, now known as the Standard Steel Car Co.

## COMING EVENTS

**March 29.**—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

**May 21-22.**—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

**May 22-25.**—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

**May 26-June 2.**—Industrial export exposition and conference, Springfield, Mass.

**June 13-15.**—Annual convention American Railway Master Mechanics' Association at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

**June 13-20.**—Annual meeting of the Railway Supply Manufacturers' Association at Atlantic City, N. J., in connection with A. R. M. M. and M. C. B. Associations' conventions. J. D. Conway, secretary and treasurer, 2136 Oliver Bldg., Pittsburg, Pa.

**June 18-20.**—Master Car Builders' Association's convention at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

**August 30-Sept. 1.**—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill., Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

## SOCIETIES, SCHOOLS AND COLLEGES

**Beloit College**, Beloit, Wis. Catalogue 1916-1917, with announcements for 1917-1918.

**Stevens Institute of Technology**, Hoboken, N. J. Annual catalogue containing the names of the members of the faculty, course of instruction, requirements for admission, sample examination papers and lists of students and alumni.

**Pratt Institute**, Brooklyn, N. Y., will present its annual exhibit of evening work Wednesday evening, March 7. The shops, laboratories and drawing-rooms of the school will be open to visitors from eight to nine, to give all interested in industrial education an opportunity to observe the students at work in the various courses, and to inspect the results and methods as well as the equipment and general facilities of the institute for conducting industrial training.

## NEW BOOKS AND PAMPHLETS

**The Tractive Resistance on Curves of a Twenty-eight-ton Electric Car.** By Edward C. Schmidt and Harold H. Dunn. 54 pages, 6 by 9 inches; illustrated. Published by the Engineering Experiment Station, Urbana, Ill., as Bulletin No. 92. Price, 25 cents.

**Industrial Arts Index.** By Marion E. Potter, Louise D. Teich and Helen M. Craig. 530 pages, 6¾ by 10 inches. Published by the H. W. Wilson Co., White Plains, N. Y.

This is the fourth annual cumulation of the subject index to a selected list of engineering and trade periodicals for 1916.

**Condensed Report of the American Uniform Boiler Code Congress**, held in Washington, D. C., December 4-5, 1916, under the auspices of the Industrial Commission of Ohio. 87 pages, 8 by 10½ inches. Published by the American Union Boiler Law Society, Erie, Pa. Thomas E. Durban, chairman, Erie City Iron Works, Erie, Pa.

**National Pipe Standards.** Appendix to 1913 Edition Book of Standards. Published by the National Tube Co., Pittsburg, Pa.

The purpose of the Appendix is to supply the latest information on the subject contained in the 1913 edition of the book of "National Pipe Standards." The information is for the most part supplementary, but in some cases replaces other data entirely.

**The New New England.** By Frank Trumbull. 24 pages, 5 by 8 inches. Published by the Chamber of Commerce of the United States of American Immigration Committee, New York City.

The booklet is a reprint of an address made before the New England Society in New York City, December 22, 1916, discussing some of the changes caused by immigration and the problems created by the influx of foreigners.

**Steam Boilers—Their Theory and Design.** By H. de B. Parsons. 377 pages, 6 by 9 inches; 157 illustrations. Published by Longmans, Green & Co., New York City. Price, $4 net.

This work, first published in 1903, has just appeared in the fifth edition. The author states in the preface that many changes have been made in the text in order to improve and bring the subject matter up to date, and that these changes have made it practically a new work. The contents by chapter heads are as follows: Physical Properties; Combustion; Fuels; Furnace Temperature and Efficiency of Boiler; Boilers and Steam Generators; Chimney Draft; Materials; Boiler Details; Boiler Fittings; Mechanical Stokers; Artificial Draft; Incrustation; Corrosion—General Wear and Tear—Explosions; Chimney Design; Smoke Prevention; Testing—Boiler Coverings—Care of Boilers and Superheated Steam.

**Manufacturing Costs and Accounts.** By A. Hamilton Church. 452 pages, 6 by 9 inches; illustrated. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $5 net.

This work was written for the purpose of gradually introducing students to the underlying principles on which manufacturing accounting of all kinds must rest. It is presented in three parts, dealing with a general outline of manufacturing accounts, cost accounting and factory reports and returns, respectively. The author has endeavored to make the principles of cost accounting as applied to manufacturing so clear that the cost man may intelligently apply them to his own peculiar problems no matter how involved they may appear to be. In view of the faulty methods of keeping costs of manufactured products so often employed there is undoubtedly need of a comprehensive work like this for the enlightenment of those responsible for cost systems.

**Failure of Brass. 1.** By Paul D. Merica and R. W. Woodward. 109 pages, 7 by 10 inches; 116 illustrations. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 82.

This report is on the microstructure and initial stresses in wrought brasses of the type 60 per cent copper and 40 per cent zinc. An experimental investigation was made at the Bureau of Standards of the causes of failure of a number of articles, particularly bolts of wrought brass of this alloy with reference to the presence of initial stress. The investigation shows that an average initial stress of 5000 pounds per square inch is to be regarded as a safe limit for rods and bolts of this type of material, under ordinary service conditions, in which the service load is itself not greater than from 5000 to 10,000 pounds per square inch.

**The Mechanical World Pocket Diary and Year Book.** 453 pages, 4 by 6 inches; illustrated. Published by Emmott & Co., Ltd., Manchester, England, and distributed in the United States by the Norman, Remington Co., Baltimore, Md. Price, 35 cents; by mail, 40 cents.

This collection of useful engineering notes, rules, tables and data has been published for thirty consecutive years. Several new features have been introduced in this edition. The section on steam and steam engines has been largely rewritten, and new tables have been introduced, giving dimensions of piston rings, governors, etc., with notes on lubrication and anti-friction bearings. The heat-treatment of steel receives attention, this section including notes on annealing, hardening, tempering, etc. The contents of the year book are so extensive and varied that no comprehensive statement can be given in the limits of this notice. Suffice it to say, that it is a most valuable and comprehensive collection of engineering data which almost any machine designer or draftsman will find useful.

**Weights and Measures.** 264 pages, 7 by 10 inches; illustrated. Published by the Bureau of Standards, Department of Commerce, Washington, D. C.

This is a report of the eleventh annual conference of representatives from various states, held at the Bureau of Standards, Washington, D. C., May 23-26. Some of the principal matters contained are short reports on legislation and general conditions existing in the United States; suggestions, discussions and resolutions as to the proper method of sale of coke, fruits, vegetables, etc., and of wrapped meats; technical papers on the selection and maintenance of apparatus in industrial plants, on the inspection, test, installation and maintenance of railroad track scales, and on liquid measuring pumps; reports and discussions in relation to the adoption and use of the metric system of weights and measures, and of the Centigrade scale of temperatures; and discussions by manufacturers of weights and measures and weighing and measuring devices, of tolerances and specifications, of new types of scales and other matters of interest.

**Manufacture of Artillery Ammunition.** By L. P. Alford, F. H. Colvin, Robert Mawson, E. H. Suverkrop and John H. Van Der Venter. 765 pages, 6 by 9 inches; 669 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $6.

This work, which is largely a reprint of articles that have appeared in the "American Machinist," was published with the aim of preserving in permanent form a record of the work done in the United States and Canada in making munitions for the European countries at war. The foreword by Howard E. Coffin, member of the Naval Consulting Board, refers to the experience gained by American manufacturers in making munitions and the value of books that place on record the means and methods employed. The subject matter is presented in four main sections, and an appendix. The first section deals with shrapnel; the second with high-explosive shells; the third with cartridge cases; and the fourth with fuses and primers. The appendix takes up machine tools for munition manufacture; composition and properties of shell steel; heat-treatment of shells, painting of shells, etc. The book contains much excellent material, and doubtless could be used advantageously in planning and equipping for the making of shrapnel and high-explosive rounds.

## NEW CATALOGUES AND CIRCULARS

**Hendey Machine Co.,** Torrington, Conn. Circular illustrating and describing the Hendey 20-inch crank shaper.

**Lees-Bradner Co.,** Cleveland, Ohio. Booklet containing formulas and operating instructions for the No. 5A Lees-Bradner gear generator.

**Peter A. Frasse & Co., Inc.,** 45 Boulevard, Hartford, Conn. Leaflet of oxy-acetylene welding and cutting, illustrating some repairs made by this process.

**St. Louis Machine Tool Co.,** St. Louis, Mo. Leaflet illustrating and giving specifications for self-contained countershafts and plain and pull countershafts.

**Monarch Engineering & Mfg. Co.,** Baltimore, Md. Catalogue entitled "The Crucible Problem Solved," illustrating Monarch melting and refining furnaces without crucibles.

**Strauss Transit System, Inc.,** 185 Jefferson Ave., E., Detroit, Mich. Catalogue illustrating the Strauss inverted elevated railway system for passenger traffic in and between cities.

**Stanley Belting Corporation,** 32-40 S. Clinton St., Chicago, Ill. Pamphlet describing and giving price list of Stanley belting, a solid woven cotton belting impregnated with a special compound.

**Haynes Stellite Co.,** Kokomo, Ind. Catalogue 6, treating of the use and application of stellite and its value for instruments, fine tools, cutlery, etc. Price lists and stock sizes of stellite bars are given.

**F. R. Blair & Co., Inc.,** 50 Church St., New York City. Circular descriptive of the "Loxon" lock-nut. It is claimed that these nut locks are as safe as a castellated nut and cotter-pin, and cheaper.

**Bickett Machine & Mfg. Co.,** 1118 Richmond St., Cincinnati, Ohio. Circular descriptive of the Bickett No. 0 vertical milling and profiling machine which has a longitudinal feed of 6 inches, a vertical feed of 2 inches, and a transverse feed of 5 inches.

**Mesta Machine Co.,** Pittsburg, Pa. Bulletin D describing Mesta automatic plate valves (Iversen patent) which are being used successfully in both new and rebuilt air and gas compressors, ammonia compressors, vacuum pumps, and blowing engines.

**Powdered Coal Engineering & Equipment Co.,** 1903 McCormick Bldg., Chicago, Ill. Bulletin 3 on the carburization and burning of powdered coal as a fuel, being a paper read before the American Institute of Mining Engineers, Chicago Section, December 22, 1916, by Alonzo G. Kinyon, chief consultant of the company.

**Fire Detecting Wire Co., Inc.,** 101 Park Ave., New York City. Pamphlet entitled "Fire Detection," treating of the fire detecting wire system for interior automatic fire alarms, which combines automatic and manual operations. It is claimed that this system positively and unfailingly alarms when the fire is insignificant, before it gets under dangerous headway.

**New Departure Mfg. Co.,** Bristol, Conn. Sheets 87 FE to 90 FE, inclusive, for loose-leaf catalogue, showing some unusual methods of ball bearing installation of interest to the machine designer. The method of mounting ball bearings in a special machine worm-drive mechanism and the application of single- and double-row bearings on a vertical spindle adapted for heavy grinding work are also illustrated.

**American Locomotive Co.,** 30 Church St., New York City. Bulletin 1018 on the Walschaert valve gear, illustrating and describing its principles in full detail. This bulletin which shows by diagrams all the principal events in a cycle for outside and inside admission valves driven by the Walschaert gear should be generally appreciated by designers, engineers, students and all who are interested in valve motion design.

**Gripwell Pulley Covering Co.,** 157 Cedar St., New York City. Pamphlet descriptive of "Gripwell" pulley covering, which is a refined vegetable oil compound of great adhesive power. It is used in connection with a specially prepared canvas, which enables the belt to exert its maximum amount of power without the necessity of being tightened and without the use of idlers. Price list of "Gripwell" pulley covering and cement is included.

**Vanadium-Alloys Steel Co.,** Pittsburg, Pa. Leaflet treating of "Vasco Special," "Vasco Electric" and "Vasco Latrobe" carbon tool steels. "Vasco Special" steel is particularly suitable for the finer grades of tools, such as taps, reamers, milling cutters, and lathe tools. "Vasco Electric" is recommended for all general tool purposes, being adapted for such work as shear blades, taps, reamers, milling cutters, etc. "Vasco Latrobe" is a low-priced steel suitable for cold chisels, granite, and similar tools.

**National Safety Council** is issuing monthly "Safe Practices" leaflets which contain the findings of fifty safety experts engaged in working out the maximum and minimum requirements in safeguarding. The three issued are entitled "Ladders," "Stairs and Stairways," and "Boiler Rooms." The National Safety Council was established to bring about an understanding of accident causes and find and apply remedial measures. Details as to the council's activities can be obtained from W. H. Cameron, general manager, National Safety Council, 208 S. La Salle St., Chicago, Ill.

**Moore & White Co.,** Philadelphia, Pa. Pamphlet entitled, "Speed Changes Without Frictional Slip," which treats of the need for a progressive speed-change device and its application in various machines, the elimination of slip in the Moore & White speed-change device, and the use of the Moore & White speed-change device on paper machinery, laundry machinery, textile machinery, cement kilns, enameling and japanning machinery, and printing presses. The principle of the Moore & White speed-change device is described and illustrated, and tables of dimensions and prices are given.

**Greenfield Tap & Die Corporation,** Greenfield, Mass. Bulletin 1, "How to Measure Screw Threads," the first of a series of treatises on threading and gaging problems to be issued by the company. The bulletin shows the wrong and right way of gaging tapped holes and the influence of variations in pitch diameter and lead on screw thread fits. The effect of wear on the accuracy of a thread micrometer is illustrated, and the defects of the ring or templet gage are shown. With these examples of erroneous and defective methods of screw thread measurements are contrasted the limit system developed by the company which tests the pitch diameter. The means for testing errors in lead are also shown. The bulletin concludes with tables of proposed tap hole limits for U. S. standard taps, S. A. E. taps and machine screw taps.

## TRADE NOTES

**Ogden R. Adams,** 159 St. Paul St., Rochester, N. Y., has opened a new salesroom for metal-working machinery at the above address.

**Canadian S. K. F. Co., Ltd.,** 47 King St., W., Toronto, Canada, has been organized under a Dominion charter, for the manufacture and sale of S. K. F. self-aligning ball bearings in Canada.

**Evans Friction Cone Co.,** Newton Highlands, Mass., is the successor of G. F. Evans, Newton Center, Mass. The company manufactures the Evans friction cone for varying the speed of machines.

**Baush Machine Tool Co.,** 200 Wason Ave., Springfield, Mass., announces that its gear department will in future be represented in the field by H. A. Daniels, who is thoroughly familiar with this line of business.

**Stroh Steel-Hardening Process Co.,** Pittsburg, Pa., has opened an office at 728 Monadnock Block, Chicago, Ill., in charge of F. Lloyd Mark, western sales manager. The Chicago office will take care of the business in the central and near western states.

**Modern Tool Co.,** Second and State Sts., Erie, Pa., manufacturer of grinding machines and threading tools, has removed its district office in Detroit, Mich., to 1223 Dime Bank Bldg. The Detroit office will continue as heretofore in charge of H. T. White.

**International Company, Inc.,** Fourth and Chestnut Sts., Philadelphia, Pa., has opened offices at this address in charge of J. Guattari, the founder and formerly president of the International Import & Export Co. The company has offices in Italy, France, Cuba and South America.

**Machine Tool & Supply Co.,** 321-323 E. Second St., Davenport, Iowa, has been incorporated to deal in new and second-hand machinery. The company has secured a store and has a large stock of machinery on hand. The state of Iowa and a portion of Illinois in the immediate vicinity of Davenport will be covered.

**Andrews & George,** Tokyo, Japan, has been reorganized and the name changed to the Andrews & George Co. on account of the death of Ernest W. George. The paid-up capital of the company has been increased and the present company assumes all assets, obligations and liabilities of the former concern, which was established about twenty-two years ago.

**General Electric Co.,** Schenectady, N. Y., has established an industrial service department for the purpose of supervising education, employment and the provision of opportunities for advancement of employes, at the Schenectady plant. The new department is in charge of E. B. Merriam, for several years assistant engineer of the switchboard department.

**Burdett Oxygen Co.,** St. Johns Court at Fulton St., Chicago, Ill., announces that it began the operation of its Oklahoma plant, located at Stock Yards Station, Oklahoma City, in February, and is now in position to furnish oxygen to users in that territory. This is the twelfth plant installed by the company in the various industrial centers of the country.

**Moline Tool Co.,** Moline, Ill., manufacturer of the "Hole Hog" line of multiple-spindle drilling machines, has moved into its new factory, which is a large sawtooth roof structure provided with modern equipment for the manufacture of machine tools. The company was obliged to expand its facilities beyond the capacity of the old plant in order to meet the demand for its machines and is now operating both new and old shops.

**Trindl Machine Works,** Fowler Bldg., 57-61 E. 24th St., Chicago, Ill., is a new concern, established by J. H. Trindl, formerly of Trindl & Ryser. The firm will engage in the manufacture and jobbing of pistons, piston rings, wrist-pins, crankshafts, valves, etc., as well as general machine work. Cylinder grinding will be made a specialty, several of the latest type grinding machines having been installed for this work.

**Newman Mfg. Co.,** 719 Sycamore St., Cincinnati, Ohio, and 68 W. Washington St., Chicago, Ill., has added another floor, 40 by 175 feet, to its Cincinnati plant, which now comprises six stories. The company manufactures machine-tool attachments, adjustable electric light brackets, brass and bronze work, signs, etc. S. J. Newman of the company states that the business is expanding rapidly and that the prospects for 1917 are excellent.

**Hannifin Mfg. Co.,** 621 Kolmar Ave., Chicago, Ill., maker of pneumatic chucks, pneumatic counter-shafts, air-operated vises, self-opening dies, etc., has just completed a large addition to its plant that will increase the floor space 8000 square feet. The company has doubled its equipment and will be able to double the output. A two-story office building has been erected and the shop has been provided with modern wash-rooms and shower baths for the employes.

**Westinghouse Electric & Mfg. Co.,** East Pittsburg, Pa., is planning the erection of a new plant in Essington, near Philadelphia, that will cost approximately $6,000,000. The new plant is being built outside the Pittsburg district for the reason that expansion in East Pittsburg is no longer possible on account of the limited space available. The company has acquired a tract in Essington of about 500 acres fronting on the Delaware River. About 100 acres will be utilized for the plant in the beginning.

**Bosch Magneto Co.,** Springfield, Mass., and Plainfield, N. J., has reorganized its purchasing department. The purchasing for both factories is now done in Springfield. The purchases are classified as product—all materials and parts entering into product— and non-product—including equipment and supplies. The purchase of product material will be in charge of S. T. Plimpton, and of non-product, of P. G. Puffer. The purchasing agents will be assisted by John Pauly and C. E. Spalding, respectively.

**Champion Tool Works Co.,** 2422 Spring Grove Ave., Cincinnati, Ohio, manufacturer of "Champion" lathes, has broken ground for a new plant which will be located at Winton Place, Cincinnati. The building, which will be 150 by 300 feet and afford 45,000 square feet floor space, will be equipped with the best facilities for manufacturing machine tools. The company expects to increase its line, making several larger sizes of lathes, and with these added facilities it will be able to make prompt deliveries.

**Hess-Bright Mfg. Co.,** Front St. and Erie Ave., Philadelphia, Pa., announces the opening of two branch sales offices—one for the eastern portion of the country at 1974 Broadway, New York City, and the other for the central section, at 1036 Guardian Bldg., Cleveland, Ohio. H. E. Brunner is in charge of the New York office, and is assisted by H. A. Fonda. The Cleveland office is under the direction of R. E. Clingan, assisted by Walter Rippien and M. S. McNay. These offices were opened in order to give better ball bearing service to the trade than has heretofore been afforded.

**Ford Motor Co.,** Detroit, Mich., has made plans for the construction of the first units of a mammoth plant on an eighty-acre tract near Newark, N. J., between the Passaic and Hackensack Rivers. Plans have been made for the immediate erection of a plant costing between $1,000,000 and $2,000,000, and the lay-out is so arranged as to permit expansion indefinitely. It is the intention to ultimately invest about $10,000,000 and to employ about 10,000 men. The annual capacity will be about three hundred to four hundred cars a day. The Detroit factory is now making 3000 cars a day, and the Canadian factory about half as many, yet the company is behind in its orders.

**Shepard Electric Crane & Hoist Co.,** Montour Falls, N. Y., is making extensive additions to its plant. A bay, 45 feet wide by 210 feet long, will be added to the east side of the structural shop, to be used as a punching and shearing shop, and a bay of the same dimensions will be added to the west side to accommodate the wash-rooms, smith shop, tool storage and machine shop. These extensions will be of brick, steel and glass set in steel sash, and will have sawtooth roofs. The additions to the machine shop will consist of an extension of the erecting and machine shop bays of about 200 feet and the construction of a new bay 85 feet wide that will extend along the entire length of the present shop and extension, to be used as a store-room. The power-room will also be enlarged. Part of the present boiler-room will be converted into a tool forging and hardening plant, while the space now used for the drafting-room and stores will be added to the tool-room. Considerable new equipment and machinery will be installed. A large brick building, located within a block of the shops, is being remodeled for an administration building.